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PERMIAN FUSULINIDS AND CEPHALOPODS FROM THE VICINITY OF THE MARACAIBO BASIN IN NORTHERN SOUTH AMERICA

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ABSTRACT—A survey of the literature indicates that fusulinids are of widespread occurrence in South America, and that they are known to range in age there from at least Middle Pennsylvanian to Upper Permian. Eleven species of these foraminifers are illustrated and described from northern Colombia and northwestern Venezuela. They are referable to *Staffella*, *Schubertella*, *Pseudoschwagerina*, *Schwagerina?*, *Parafusulina*, and possibly *Polydiexodina*, and they indicate that the zones of *Pseudoschwagerina* (Wolfcampian), *Parafusulina* (Leonardian and lower Guadalupian), and possibly *Polydiexodina* (upper Guadalupian) are represented there. The only Permian cephalopods illustrated and/or described from South America are representatives of three genera of nautiloids (*Mooreoceras*, *Pseudometacoceras?*, and *Domatoceras*) and two of ammonoids (*Medlicottia* and *Perrinites*) from the Leonardian of northern Colombia.

INTRODUCTION

EARLY in 1945 J. Wyatt Durham sent us for study about a dozen collections of Late Paleozoic fossils from the Sierra de Perijá in northern Colombia just west of the Maracaibo basin. He included one assemblage from the Andes de Mérida in northwestern Venezuela, just east of the same basin. A few months later we received from K. F. Dallmus two additional collections from the latter mountain range—one of these came from east and one from southeast of the Maracaibo basin. These materials constitute the basis for the present report, and we wish to take advantage of this opportunity to acknowledge our indebtedness to Messrs. Durham and Dallmus for entrusting us with the collections, most of which they assembled in the field.

GENERAL STRATIGRAPHY

Upper Paleozoic rocks have been reported from several localities in Venezuela and Colombia, but they have been described in detail from only a very few of them. Christ (1927) proposed the name Palmarito series for about 300 meters of variously colored fossiliferous limestone and brownish, grayish, greenish, and variegated fossiliferous marls exposed near Palmarito in the Andes de Mérida, and he stated that these strata contain fusulinids, brachiopods, cephalopods, and trilobites. Gerth (1931) listed two species of Foraminifera (one of fusulinids), six of brachiopods, two of corals, one of gastropods, and one of trilobites from the type section of the Palmarito. From a nearby area, Kehrer (1938) gave a list of 22 species identified by James Steele Williams. Christ

and Gerth believed the Palmarito to be Carboniferous in age, but Kehrer concluded that it is Upper Carboniferous and Permian. The Upper Paleozoic strata exposed in the vicinity of the northern part of the Colombian-Venezuelan border seem to be much thicker than those of the Andes de Mérida. That is, great thicknesses of Carboniferous and Permian rocks have been reported from Gachalá, Bucaramanga, and the Sierra de Perijá by Trumpy (1943). He states that there are 2,400 meters of Carboniferous beds near Labateca, and he lists eight species which may indicate an Upper Carboniferous (Pennsylvanian) age.

The age of most of the Late Paleozoic strata exposed in the Sierra de Perijá has not been determined, but Trumpy lists a considerable variety of fossil invertebrates from them that were identified by James Steele Williams and A. K. Miller. Among these is *Perrinites* cf. *P. hilli*, which was later illustrated and described by Miller and Williams (1945) along with a few other cephalopods. These latter authors concluded that the fossiliferous beds there are Leonardian in age inasmuch as they contain *Perrinites* and no forms that seem to militate against that conclusion.

PREVIOUS WORK ON SOUTH AMERICAN FUSULINIDS

Various authors have reported fusulinids from Bolivia, Brazil, Colombia, Peru, and Venezuela, and it appears that locally they are abundant. Nevertheless, so little detailed information is available in regard to most of the South American forms that satisfactory comparison cannot be made with them. It has been clearly demonstrated that in numerous areas on other continents fusulinids are among the more reliable index fossils in Pennsylvanian and Permian strata, and the South American forms are almost certainly of equal importance. Insofar as we are aware, only five published reports include illustrations and descriptions of South American fusulinids (Meyer, 1914; Gerth, 1931; Berry, 1933; Thompson, 1943; and Dunbar and Newell, 1946).

Meyer (1914) described three species of fusulinids from Peru and Bolivia as *Schellwienia convoluta* Meyer [Morochata, Bolivia], *S.* aff. *S. vulgaris* (Schellwien) [Angostura de Yaco, Bolivia], and *S. peruana* Meyer [Tarma, Peru]. The first of these three forms, seemingly of Permian age, has been referred with question by Dunbar and Newell (1946) to *Schwagerina prolongada* (Berry); and the last one, of lower Middle Pennsylvanian age, has been described by these same authors as *Fusulinella peruana* (Meyer).

From Paseo Palmarito in the southern part of the Andes de Mérida of Venezuela, Gerth (1931) described and illustrated a fusulinid which he designated *Fusulina* cf. *verneuili* Möller. It seems probable that this form may be referable to *Parafusulina*, and it almost certainly is of Permian age.

Berry (1933) described and illustrated three fusulinids from the Lake Titicaca region of Peru and Bolivia as *Fusulina prolongada* Berry, *Fusulina peruana* (Meyer), and *Fusulina berryi* Berry. Berry's original collections have been restudied by Dunbar and Newell (1946) and described as *Schwagerina prolongada* (Berry), *S. berryi* (Berry), and *Triticites patulus* Dunbar and Newell [=*Schwagerina patulus* (Dunbar and Newell)]. All of these forms are of Lower Permian (Wolfcampian) age.

Thompson (1943) described and illustrated as *Schwagerina* aff. *S. laxissima* Dunbar and Skinner a fusulinid of the same general age from a deep well in the Agua Caliente oil field on the east flank of the Andes in the Departamento de Lareto, Peru. This form was later described by Dunbar and Newell as *Schwagerina? patens* Dunbar and Newell. We refer it with question to the genus *Pseudofusulina*.

Dunbar and Newell (1946) described and illustrated seventeen species of fusulinids from the Lake Titicaca region of Peru and Bolivia and from central Peru. Sixteen of these forms are of Lower Permian (Wolfcampian) age, and one of them, *Fusulinella peruana* (Meyer), is of lower Middle Pennsylvanian age. These seventeen species include all except one or possibly three of the formerly described South American fusulinids—the exceptions are the form from Venezuela described by Gerth as *Fusulina* cf. *verneuili* Möller, and possibly the two forms from Bolivia described by Meyer as *Schellwienia convoluta* Meyer and *Schell-*

wiena aff. *vulgaris* (Schellwien). Dunbar and Newell's faunas contain the following forms:

PENNSYLVANIAN

Fusulinella peruana (Meyer)

PERMIAN

Triticites nitens Dunbar and Newell
T. boliviensis Dunbar and Newell
Schwagerina berryi (Berry)
S. patulus (Dunbar and Newell)
S. opimus (Dunbar and Newell)
S. titicacaensis (Dunbar and Newell)
S. muñaniensis Dunbar and Newell
S. ahlfeldi Dunbar and Newell
S. steinmanni Dunbar and Newell
S. prolongada (Berry)
S. cf. *S. emaciata* (Beede)
S. sp. *A*
Pseudofusulina? patens (Dunbar and Newell)
Pseudoschwagerina uddeni (Beede and Knicker)
P. kozlowskii Dunbar and Newell
P. d'orbignyi Dunbar and Newell

The occurrence of fusulinids in other areas of South America has been recorded in several reports of a general or regional nature (Derby, 1894; Katzer, 1903; Steinmann, 1929; Gerth, 1932; Hedberg and Sass, 1937; Trumpy, 1943; Oliveira and Leonardos, 1943; Schaub, 1944; and Sutton, 1946). For the most part these references are to specimens that have not been described, illustrated, or identified specifically. A few workers have compared South American fusulinids to forms originally described from the eastern hemisphere. Derby (1894), Katzer (1903), and Oliveira and Leonardos (1943) have mentioned "*Fusulina*" from Itiatuba, Pará, Brazil, but nothing further is known concerning this form or forms. Steinmann (1929) cited the occurrence of fusulinids at numerous places in Peru and listed a few of them by name. Gerth (1932) mentioned fusulinids that had been recorded formerly from areas in South America. Trumpy (1943) listed *Paraschwagerina yabei* (Staff) from boulders in conglomerates of the volcanic red beds on Río Mula, south of Manaure in the Sierra de Perijá of northern Colombia. *P. yabei* was originally described from the Sosio beds of Sicily, that is, from rocks generally considered to be of Guadalupian age. Trumpy also reported that O. Renz had found Permian fusulinids in boulders in the red beds in the Caesar Valley of the Chiriquana area of Colombia.

Hedberg and Sass (1937) reported a fusulinid from Caño Pascado in the upper region of Río Palmar on the east flank of the southern end of the Sierra de Perijá and on the west flank of the Maracaibo basin in northwestern Venezuela. F. Hodson (Schaub 1944, p. 1643) had identified this fusulinid as *Fusulinella* cf. *F. compressa* Ozawa. Sutton (1946) recorded fusulinids from the Palmarito series in the states of Mérida (type area) and Barinas (Río Boconó) of western Venezuela. He stated that the fusulinids from the Palmarito area in Mérida were collected by P. P. Wolcott and that those from Río Boconó in Barinas were secured by J. W. Nance. Also, Sutton recorded that R. A. Rank and F. Hodson had discovered fusulinids in Caño del Oeste branch of Río Cachiri and in Caño Pascado tributary of Río Palmar on the east slope of the Sierra de Perijá. Schaub (1944) discussed the occurrence of fusulinids of the subfamily Schwagerininae in pebbles of the basal conglomerate of the La Quinta formation (sometimes called Giron formation) exposed between Kilometers 10 and 16 along the road from Trujillo to San Lazaro, in northwestern Venezuela.

FUSULINID COLLECTIONS STUDIED

Through the kindness of Messrs. J. Wyatt Durham and K. F. Dallmus, we have had an opportunity to study six collections of fusulinids from northern Colombia and three from northwestern Venezuela. The former are numbered 5006, 9186, 12087, 19061, 19062, and 19063; and the latter 19150, 30473, and 35164. The locality, lithology, and fusulinid fauna of each of these is given in the following paragraphs, and their distribution is elucidated by the accompanying map (Fig. 1).

COLOMBIA

Collection 5006. From bluish-gray highly crinoidal limestone float in Quebrada Manaure, along the road from La Paz to Manaure and about 6 kilometers east of La Paz,

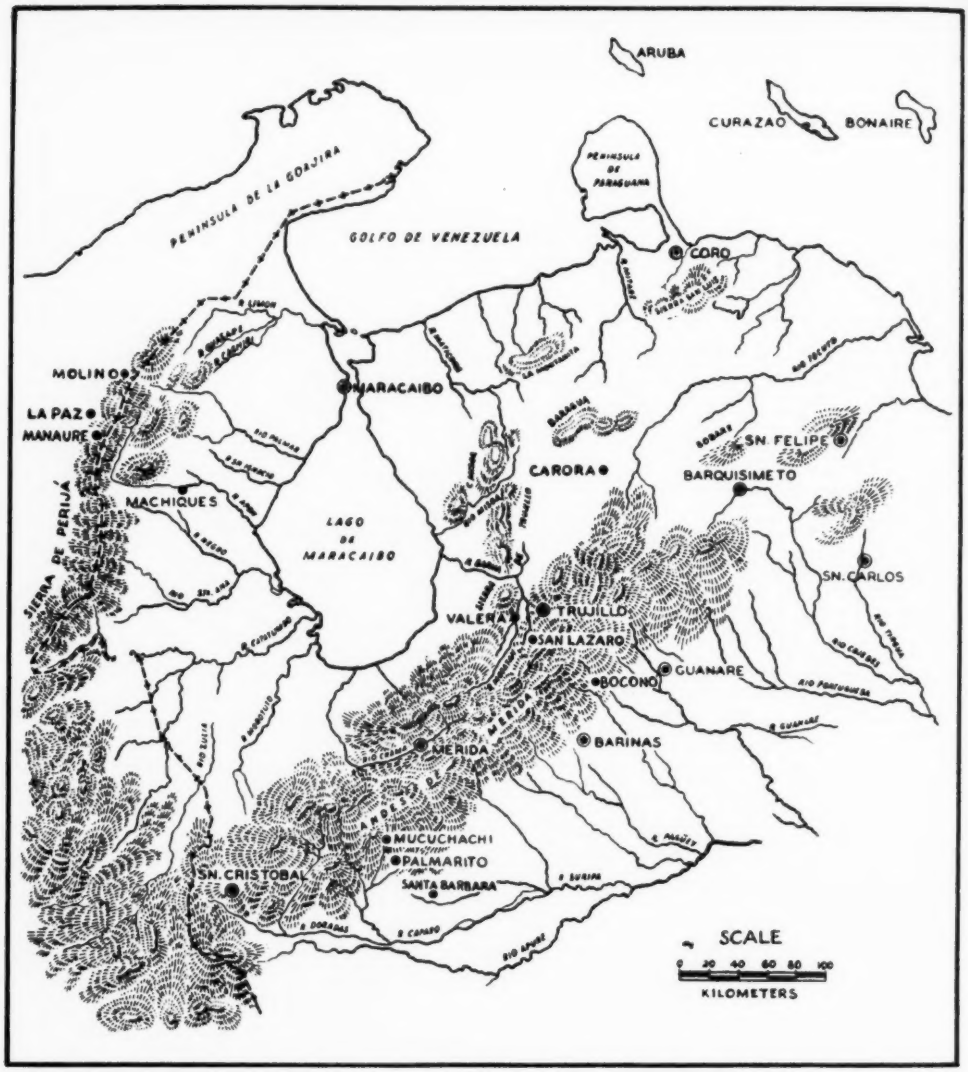


FIG. *1*—Physiographic diagram of the Maracaibo basin area showing towns near which fossils were collected. Slightly modified from Sutton.

Departamento de Magdalena.

Fusulinids: *Schwagerina? hedbergi*, n. sp.
Collector: B. B. Colley; January, 1943.
Collection 9186. From bluish-gray dense limestone exposed along a hillside on the north side of Quebrada Manaure about 4.5 kilometers east of the village of Manaure, Departamento de Magdalena.

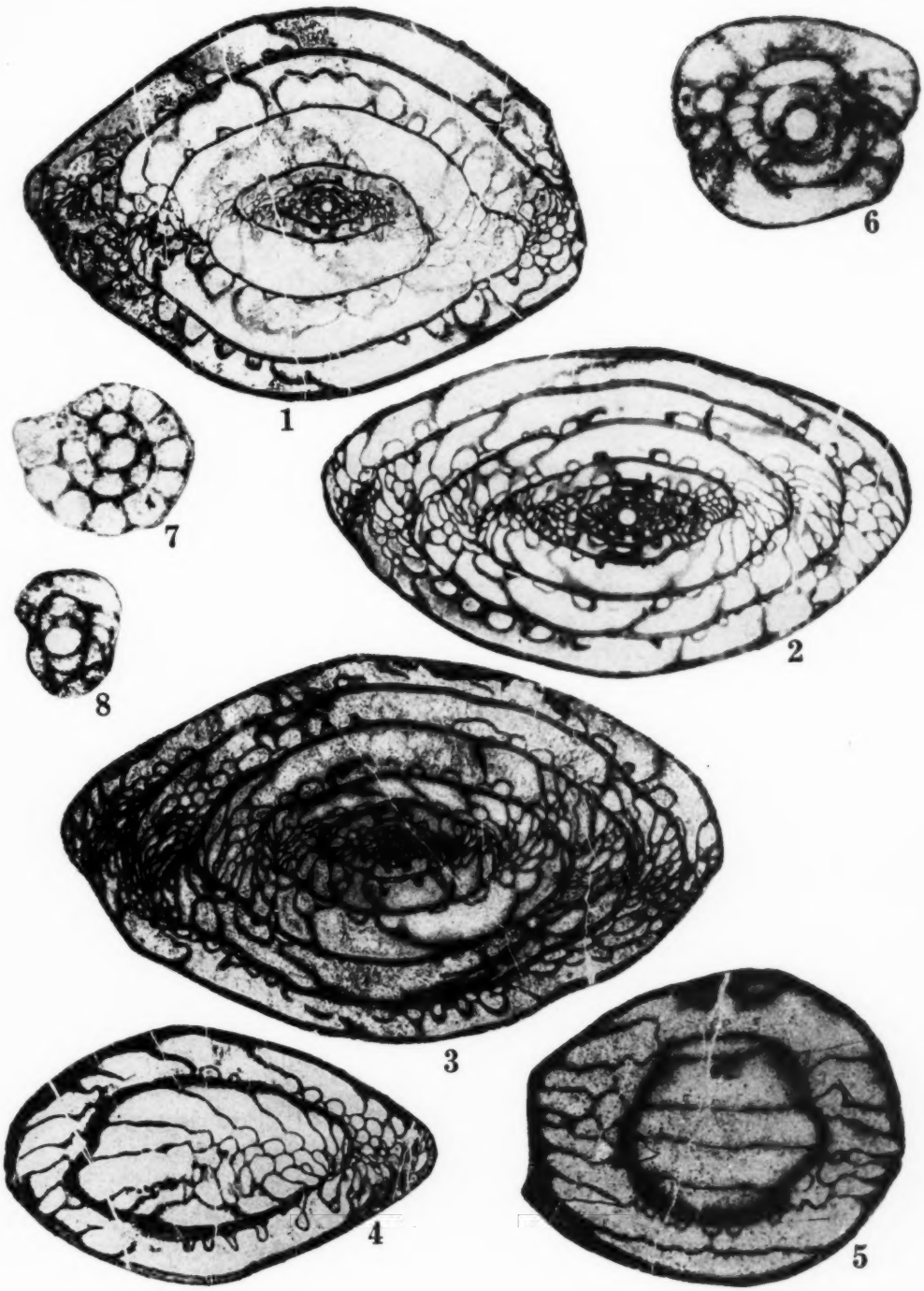
EXPLANATION OF PLATE 1

All illustrations on this plate are unretouched photographs. Figures *1–5* are ×10, *6–8* are ×100.

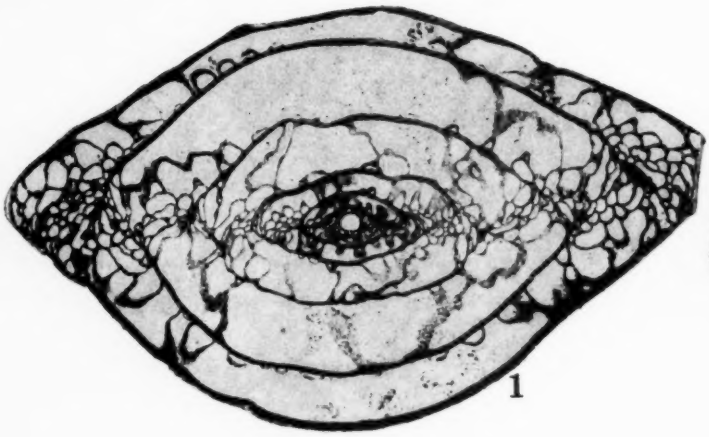
FIGS. *1*, *5*—*Pseudoschwagerina dallmusi* Thompson and Miller, n. sp. Axial (fig. *1*) and tangential (fig. *5*) sections of paratypes. Collection 9186, Colombia. (See also plates 2, 6.) (p. 10)

2–4—*Pseudoschwagerina dallmusi* Thompson and Miller?, n. sp. Axial (figs. *2*, *3*) and oblique tangential (fig. *4*) sections. Collection 9186, Colombia. (see also plates 2, 6.) (p. 10)

6–8—*Schubertella australis* Thompson and Miller, n. sp. Axial section of holotype (fig. *6*), and sagittal (fig. *7*) and axial (fig. *8*) sections of paratypes. Collection 9186, Colombia. (p. 9)



Thompson and Miller, Permian Fossils from Maracaibo Region



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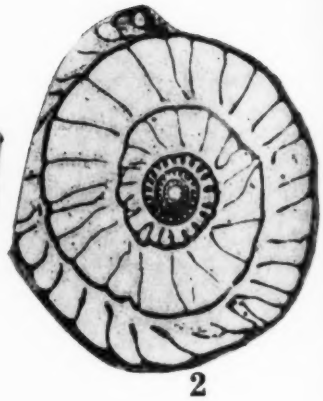

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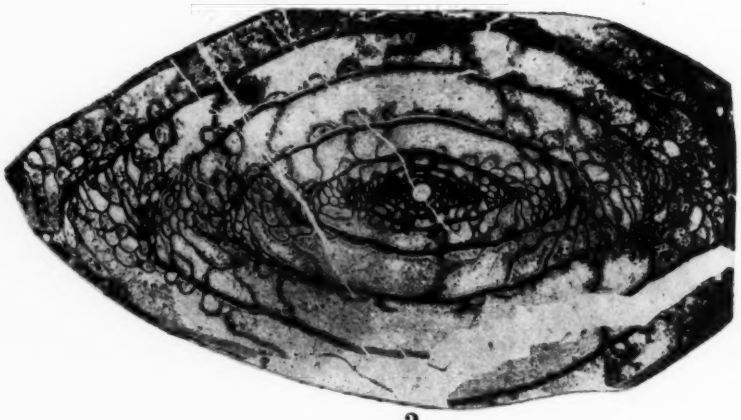

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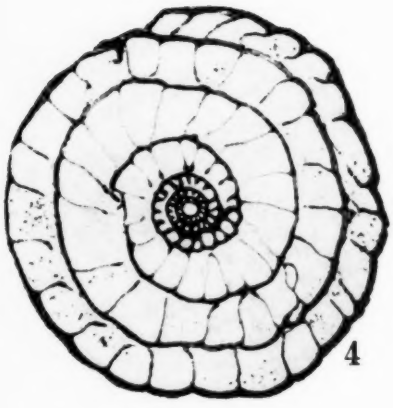

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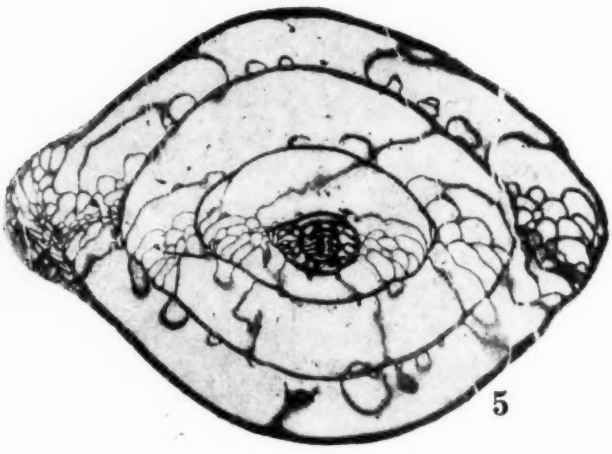

5

Thompson and Miller, Permian Fossils from Maracaibo Region

Fusulinids: *Schubertella australis*, n. sp., and *Pseudoschwagerina dallmusi*, n. sp.

Collector: J. Wyatt Durham; April 1943.

Collection 12087. From light brown chert float in Río Molino, about 6 kilometers upstream from the village of Molino, Departamento de Magdalena. This sample contains an abundance of specimens of *Parafusulina trumpyi*, n. sp. They are entirely replaced by chert, but some of them still show all the structures necessary for identification. This locality was the source of the cephalopod illustrated by figure 4 on plate 8 and identified as *Mooreoceras* sp.

Fusulinids: *Parafusulina trumpyi*, n. sp.

Collector: O. L. Haught; March, 1944.

Collection 19061. From medium to dark gray highly cherty limestone float in Río Molino, about 6 kilometers upstream from the village of Molino, Departamento de Magdalena. This collection came from near the same locality as Collection 12087.

Fusulinids: *Parafusulina trumpyi*, n. sp.

Collector: J. Wyatt Durham; September, 1944.

Collection 19062. From a dark gray limestone exposed along the hillside on the north side of Quebrada Manaure, about 4.5 kilometers east of the village of Manaure, Departamento de Magdalena. Thin sections reveal numerous arenaceous foraminifers and only occasional specimens of an unidentified species of *Schwagerina*.

Fusulinids: *Schwagerina* sp.

Collector: J. Wyatt Durham; September, 1944.

Collection 19063. From a bluish-gray limestone exposed on a hillside on the north side of Quebrada Manaure, about 4.5 kilometers east of the village of Manaure, Departamento de Magdalena. The limestone at this locality is dense and is cut by numerous veins of white calcite.

Fusulinids: *Parafusulina durhami*, n. sp.

Collector: J. Wyatt Durham; September, 1944.

VENEZUELA

Collection 19150. Several fusulinid-bearing pebbles from the basal conglomerate of the La Quinta formation, on the Trujillo-San Lazaro road, 15.5 kilometers from Trujillo. This collection is from the same conglomerate and probably from one of the same localities at which Schaub (1944) recorded the occurrence of fossiliferous limestone pebbles.

Fusulinids: *Staffella* sp., *Parafusulina* sp. A, *P.* sp. B., and *P.?* sp. C.

Collector: J. Wyatt Durham; March 10, 1945.

Collection 30473. From the gorge of the Río Boconó, below the town of Boconó, Barinas. Sample was obtained from a highly fractured gray limestone which is cut by many calcite veins, which weathers "knotty," and which shatters easily. This hand sample is dark gray and it shows evidence of having been highly compressed. Most of the fusulinids are broken along planes that suggest crude cleavage. This sample may be from the collection made by J. W. Nance and mentioned by Sutton (1946).

Fusulinids: *Parafusulina nancei*, n. sp.

Collector: J. W. Nance; February 15, 1940.

Collection 35164. From the Palmarito road between Santa Barbara de Barinas and Mucuchachi, from conglomerate at the base of

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EXPLANATION OF PLATE 2

All illustrations on this plate are unretouched photographs, ×10.

FIGS. *1, 2, 5*—*Pseudoschwagerina dallmusi* Thompson and Miller, n. sp. Axial section of holotype (fig. *1*), and sagittal (fig. *2*) and tangential (fig. *5*) sections of paratypes. Collection 9186, Colombia. (See also plates 1, 6.) (p. 10)

3, 4—*Pseudoschwagerina dallmusi* Thompson and Miller?, n. sp. Axial (fig. *3*) and sagittal (fig. *4*) sections. Collection 9186, Colombia. (p. 10)

the Triassic? red beds that rest unconformably on Upper Paleozoic red beds interbedded with dark gray to black limestones. The limestone pebbles in the samples we have are well rounded and the largest measures more than 100 mm. in maximum diameter. Most of the pebbles are medium gray to light-pinkish-gray in color. Some are dark gray. One pebble is composed of red siltstone. All of the limestone pebbles are highly fossiliferous. The largest pebble contains many brachiopod shells, and several smaller ones contain abundant fusulinids.

Fusulinids: *Parafusulina?* sp. D.

Collector: K. F. Dallmus; March 16, 1942.

AGE OF THE FUSULINID FAUNAS

The form described and illustrated below as *Staffella* sp. is exceedingly abundant in a pebble of dark gray to black siliceous fossiliferous limestone collected from the basal conglomerate of the La Quinta formation on the Trujillo-San Lazaro road in northwestern Venezuela (Collection 19150). No other types of fusulinids are associated in the same pebble with it. However, abundant specimens that we are designating *Parafusulina* sp. A, *P.* sp. B, and *P.* sp. C occur in pebbles of light gray dense limestone collected from the conglomerate at the same locality. The genus *Staffella* has been recorded from rocks ranging in age from the lower part of the Middle Pennsylvanian to the Upper Permian. None of its species is believed to be of great value for detailed correlation. Therefore, the occurrence of a representative of *Staffella* in a dark gray limestone pebble in the basal conglomerate of the La Quinta formation does not furnish information as to the exact age of the source bed of the pebble further than that it is of Pennsylvanian or Permian age.

Collection 9186 from east of the village of Manaure in northern Colombia contains abundant specimens described below as *Pseudoschwagerina dallmusi*, n. sp. This form is closely similar to representatives of the genus known from the Hueco limestone of Texas and New Mexico, the Wolfcamp formation of west Texas, the Bird Springs formation of southern California, the McCloud limestone of northern California, and Wolfcampian rocks of Oklahoma, Kansas, and north-central Texas. Also, similar forms have been described from the Permian of Peru and Bolivia. The genus *Pseudoschwagerina* Dunbar and Skinner, 1936 [*Schwagerina* Möller, 1877, of most authors prior to 1936] has long been considered an index to the Lower Permian. The available evidence indicates that the limestone from which *P. dallmusi* was collected is of Wolfcampian age.

The genus *Schwagerina* has a stratigraphic range from near the base of the Permian to the highest fusulinid-bearing part of that system. A form is described below as *Schwagerina? hedbergi*, n. sp. It is abundant in Collection 5006 from east of La Paz, Colombia. *S.? hedbergi* belongs in a species group that ranges from the upper part of the Wolfcampian to the Upper Permian. These forms are relatively abundant in the Middle and Upper Permian of the eastern hemisphere and are found in the Upper Permian of extreme northwestern North America. All of them are rather large and have thick axial fillings. It is not certain that they are congeneric with *Schwagerina princeps* (Ehrenberg), the genotype of *Schwagerina*. Outside the "Tethys Sea" area of British Columbia and Washington, this type of fusulinid is not known with certainty to occur in America above the Wolfcampian. A somewhat similar though smaller form, *S. ahlfeldi* Dunbar and Newell, has been described from the Capacabana group of Bolivia. The authors of that species suggested that the part of the Capacabana which yielded the type specimens may possibly be of Leonardian age. In general, *Schwagerina gruperaensis* Thompson and Miller from the Grupera formation of Chiapas resembles *S.? hedbergi* in several respects. The Grupera formation is considered to be upper Wolfcampian in age (Thompson and Miller, 1944).

Three large species of *Parafusulina*, for which we are proposing the names *P. durhami*, *P. trumpyi*, and *P. nancei*, are abundant in certain of the collections from northern Colombia and northwestern Venezuela that are under consideration. *P. durhami* is from about 4.5 kilometers east of Manaure, Colombia; *P. trumpyi* is from Río Molino about 6 kilometers upstream from Molino, Colombia; and *P. nancei* is from the gorge

of Río Boconó below the village of Boconó, Barinas, Venezuela. The high degree of development of these large forms suggests that they are of Leonardian or lower Guadalupian age. Most of the fusulinids described from the type Leonardian section of Texas are from the lower part of that series and were originally referred to the genus *Schwagerina*. *Parafusulina* dominates the upper Leonardian fusulinid faunas, but most of the forms are undescribed. Only one species of *Parafusulina*, *P. bakeri* Dunbar and Skinner, is known from possible type Leonardian beds. However, three species of *Parafusulina* have been described from the Leonardian Bone Springs limestone of west Texas. *P. trumpyi* resembles *P. fountaini* Dunbar and Skinner which probably came from the Bone Springs limestone and *P. sellardsi* Dunbar and Skinner of the Word formation, also of west Texas. Therefore the limestones from which *P. trumpyi*, *P. durhami*, and *P. nancei* were collected are most probably Leonardian or lower Guadalupian in age. However, Durham advises us that in the field his Collection 19063 with *Parafusulina durhami* seemed to be stratigraphically lower than that numbered 9186 with *Pseudoschwagerina dallmusi*, "unless there are structural complications which were not noted in the very rapid reconnaisance."

Specimens of unidentified species of *Parafusulina* occur in limestone pebbles of the basal conglomerate of the La Quinta formation exposed along the Santa Barbara-Mucuchachi and the Trujillo-San Lazaro roads in northwestern Venezuela. Most of these seem to be intermediate forms of the genus, and presumably therefore the pebbles were derived from Permian limestones of Leonardian age. However, some of the specimens are rather primitive representatives of *Parafusulina*. Also, one of the forms which was obtained from a pebble of Collection 19150 from along the road between Trujillo and San Lazaro, and which is described below as *Parafusulina?* sp. D, may be referable to *Polydiexodina*. That genus is restricted in North America to the upper Guadalupian, and therefore it is possible that some of the pebbles in the conglomerates of the La Quinta formation may have been derived from rocks of upper Guadalupian age.

CEPHALOPODS

In 1927 Christ mentioned that cephalopods occur in the Palmarito series of northwestern Venezuela but gave no additional information in regard to them. With the possible exception of these forms, all of the Permian cephalopods known from South America came from the Sierra de Perijá just west of the northern part of the Colombian-Venezuelan boundary. Those studied previously were collected by O. Renz from very fossiliferous gray dolomitic limestone in a fault block between Upper Cretaceous and Devonian strata "east of Manaure" in the Departamento de Magdalena, Colombia. They were described in 1945 by Miller and Williams as *Titanoceras?* sp. [=*Pseudometacoceras?* sp.], *Medlicottia* sp., and *Perrinites hilli* Smith?. The first two of these forms were regarded as not particularly significant, but the third was believed to indicate clearly that the fauna is of Leonardian age.

Additional material has been sent us by Dr. J. Wyatt Durham. With the exception of a single rather inconsequential specimen (*Mooreoceras* sp. —pl. 8. fig. 4) which O. L. Haught found in very dark gray limestone float in Río Molino about 6 kilometers upstream from the village of Molino in the Departamento de Magdalena (Collection 12086), all of the new collections came from the same general locality as those known previously, that is, from east of Manaure. One of them (numbered 9187) consists of two representatives of *Perrinites hilli?* (pl. 8, fig. 1) that Durham found along the front of the hill on the north side of Quebrada Manaure about 4 kilometers east of the village of Manaure. A second (numbered 12109) is composed of one specimen of each of the following three forms: *Mooreoceras* sp. (pl. 8, fig. 3), *Medlicottia* cf. *M. whitneyi* Böse (pl. 8, figs. 6, 7), and *Perrinites hilli?*; these were collected in April of 1944 by O. L. Haught along the trail on the top of the ridge on the north side of Quebrada Manaure about 4 kilometers east of the village of Manaure. Three blocks of hard light gray limestone in which several representatives of *Perrinites hilli?* are imbedded constitute a third collection (numbered 9185), made by J. Wyatt Durham in April of 1943 along the north side of Quebrada Manaure about 4.5

kilometers east of the village of Manaure. The fourth collection (numbered 19062) consists of a specimen which may be a scaphopod but which we are tentatively identifying as *Mooreoceras?* sp. (pl. 8, fig. 5), one that is referable to *Domatoceras* (pl. 8, fig. 8), and two that probably belong in *Perrinites hilli* (pl. 8, fig. 2)—these were secured by Durham in 1944 from the same locality as the preceding, that is, as Collection 9185.

Of the cephalopods known from east of Manaure, the nautiloids (particularly the straight ones) are of little help in determining the precise age of the containing beds. That is, *Mooreoceras*, *Pseudometacoceras*, and *Domatoceras* all have a long range in the late Paleozoic, and therefore they can be said to indicate little more than that the fauna is either Pennsylvanian or Permian in age. Neither of the two specimens of *Medlicottia* now known from this area is well enough preserved to permit its specific identification with a reasonable degree of certainty, but all of the characters of each that can be ascertained seem to coincide well with those of typical *M. whitneyi* Böse of the Leonardian of Texas and Coahuila. It should perhaps be emphasized in this connection that this general type of medlicottid is known to range from early Leonardian time to the close of the Permian, and only exceptionally well preserved specimens can be identified specifically. The other ammonoid species, *Perrinites hilli?*, which is fairly abundant at the localities east of Manaure, belongs in a genus that has for a long time been regarded as diagnostic of the Leonardian. Clifton (1945) and Skinner (1946) have recently placed in the Word formation (lower Guadalupian) some of the beds in southwestern United States that contain *Perrinites*, but we prefer the classical interpretation. This genus is now known to be of rather widespread occurrence in North America, having been found in Texas, Oklahoma, New Mexico, Arizona, Coahuila, and Chiapas, and it is also known to be represented in Timor and possibly the Pamir Highlands of Soviet Russia.

FAUNAL SUMMARY

Although our knowledge of the fusulinids of South America is meager, the published data indicate that these foraminifers are of widespread occurrence there and that locally they are quite abundant. Only one Pennsylvanian or Upper Carboniferous species, *Fusulinella peruana* (Meyer), has been described from the entire continent, but Middle Pennsylvanian (Zone of *Profusulinella*) forms are known to occur in the Andean region. Permian fusulinids of the Zone of *Pseudoschwagerina* are widespread in the Lake Titicaca area of Peru and Bolivia. The collections from northern Colombia and northwestern Venezuela on which the present report is based contain eleven species belonging in five or six genera. They seem to represent the zones of *Pseudoschwagerina*, *Parafusulina*, and possibly *Polydiexodina*, and presumably, therefore, are Lower, Middle, and possibly Upper Permian in age.

The only Permian cephalopods that have been illustrated and/or described from South America are representatives of three genera of nautiloids (*Mooreoceras*, *Pseudometacoceras?* and *Domatoceras*) and two of ammonoids (*Medlicottia* and *Perrinites*). All came from a few closely adjacent localities in northern Colombia, and they are believed to be from one fauna which is Middle Permian (Leonardian) in age.

Attention should be called to the fact that some of the collections from the north side of Quebrada Manaure about 4.5 kilometers east of the village of Manaure in northern Colombia contain fusulinids whereas others from the same general locality consist of cephalopods. Altogether from there we have representatives of the following species.

Fusulinids

Schubertella australis, n. sp.
Pseudoschwagerina dallmusi, n. sp.
Schwagerina sp.
Parafusulina durhami, n. sp.

Cephalopods

Mooreoceras? sp.
Domatoceras sp.
Perrinites hilli Smith?

The matrix in which these all are preserved is hard gray limestone, but that of the several collections seems to be quite varied. If this entire assemblage is from one formation, its age is almost certainly Leonardian. However, some of the fusulinids, particularly

Pseudoschwagerina dallmusi, indicate that part of the beds at this locality are Wolfcampian, whereas another, *Parafusulina durhami*, suggest that part of them are upper Leonardian or lower Guadalupian; and we believe that most probably the cephalopod genus *Perrinites* is limited to the Leonardian.

The type and figured fusulinids of this report are to be deposited in the collection of M. L. Thompson. All of the cephalopods, and duplicates of the fusulinids, are to go to the University of California at Berkeley.

DESCRIPTION OF FUSULINIDS

STAFFELLA sp.

Plate 7, figures 8–12

A single pebble in Collection 19150 from the basal conglomerate of the Triassic? red beds contains numerous spherical fusulinids that have been largely replaced by secondary mineralization. They all seem to be referable to one species. Their general shape and the internal features that can be determined resemble those of the genotype of *Staffella*, *S. moellerana* Thompson. We are therefore referring them tentatively to that genus but they are so poorly preserved that even their generic affinities cannot be determined with certainty. Although many of the more significant characters of these specimens cannot be ascertained, we are illustrating several individuals to show their general features.

The largest specimens consist of nine to eleven volutions and are 2.09–2.56 mm. wide and at least 1.75 mm. long. The polar areas are deeply umbilicate. The heights of the chambers of the first to the eleventh volutions of one of the specimens are about 47, 63, 77, 103, 128, 151, 163, 165, 175, 175, and 186 microns, respectively. The spirothecal structure cannot be determined, but the spirotheca is about 30 microns thick in the sixth volution. The septa are rather widely spaced. The septal counts of the third to ninth volutions of one specimen are 9, 13, 14, 16, 19, 22, and 24, respectively. The tunnel seems singular. Massive chomata appear to be present in at least some parts of the shell.

Occurrence.—All specimens of this form came from a single pebble obtained from the basal conglomerate (Collection 19150) of the Triassic? red beds along the Trujillo-San Lazaro road about 15.5 kilometers from Trujillo. No other fusulinids were found in the same pebble. However, the forms described below as *Parafusulina* sp. A, *P.* sp. B, and *P.* sp. C were obtained from pebbles in the same collection.

SCHUBERTELLA AUSTRALIS Thompson and Miller, n. sp.

Plate 1, figures 6–8

Shell minute, short, inflated; with blunt to slightly umbilicate polar ends and convex lateral slopes. Mature shells of two to three volutions are 0.16–0.36 mm. long and 0.18–0.30 mm. wide, and have form ratios of 0.9–1.2. General shape of shell changes rapidly with growth of individual. Axis of coiling of first volution short, that of second volution is about the same as width of shell, and that of third volution is slightly greater than width of shell. Form ratios of first to third volutions of holotype about 0.78, 1.02, and 1.20, respectively. Axis of coiling of first volution at large angle to that of third volution. Axis of second volution at small angle to that of third volution.

Proloculus relatively large. Its outside diameter measures 48–58 microns in five specimens, averaging 53 microns. Chambers increase in height slowly with growth of shell, averaging 30, 39, and 53 microns, respectively, in first to third volutions of six specimens. Heights of chambers not uniform throughout length of shell—above measurements were made near center of shell.

Spirotheca thin, and appears to consist of a single dense layer. A diaphanotheca or comparable layer cannot be differentiated in the thin spirotheca. It should be pointed out, however, that many specimens of *Pseudoschwagerina dallmusi* associated with this form have carbonate rhombs that replace portions of their spirotheca, indicating that secondary mineralization has altered the fossil forms, at least to some extent. Also, the minute size of *S. australis* makes it difficult to observe clearly very thin structures of the spirotheca.

Septa widely spaced, and their structure resembles that of the spirotheca. Septal counts of first and second volutions of one

specimen are 6 and 12, respectively. Septa plane throughout length of shell.

Tunnel low and broad. Chomata low and indistinct. Tunnel angle about 32 degrees in third volution of holotype.

Remarks.—*Schubertella australis* is one of the smallest forms to be referred to this genus. The thin spirotheca seems primitive in nature and cannot be compared favorably with that of the genotype, *S. transitoria* Staff and Wedekind. The spirotheca of *S. transitoria* is composed of a tectum and an inner less dense layer. However, the spirotheca of *S. australis* is similar to that of several other Permian forms referred to *Schubertella*, including *S. mullerriedi* Thompson and Miller from the Paseo Hondo formation of Chiapas and *S. melonica* Dunbar and Skinner from the Hess limestone of Texas. Late forms of many branches of the fusulinid family developed thin structureless spirotheca, and that of *S. australis* may indicate an aberrant development.

Schubertella australis does not resemble closely any previously described forms, and therefore specific comparisons seem unnecessary.

Occurrence.—*Schubertella australis* is rather common in one collection (9186) from the north side of Quebrada Manaure, about 4.5 kilometers east of the village of Manaure Departamento de Magdalena, Colombia, where it is associated with abundant specimens of *Pseudoschwagerina dallmusi*, n. sp.

TABLE OF MEASUREMENTS OF *Schubertella australis*
(in millimeters)
(Specimens 1, 5, 6 are illustrated as figures 6, 8, 7, respectively, on plate 1.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	Form ratio of volutions 1	2	3
1	0.36	0.30	3	.058	.034	.036	.065	0.78	1.02	1.20
2	0.25	0.21	2½	.052	.025	.029	.039	0.83	0.92	1.19
3	—	0.21	2½	.053	.039	.040	—	0.78	0.75	—
4	0.26	0.30	3	—	.028	.034	.057	0.64	0.81	0.87
5	0.16	0.18	2	.048	.027	.032	—	—	—	—
6	—	0.23	2	.053	.027	.044	—	—	—	—

PSEUDOSCHWAGERINA DALLMUSI Thompson and Miller, n. sp.
Plate 1, figures 1–5; Plate 2, figures 1–5; Plate 6, figure 10

A sample of limestone in Collection 9186 contains numerous specimens of two kinds of *Pseudoschwagerina*. One of these is robust with a short axis of coiling and highly inflated chambers in the outer volutions (pl. 1, figs. 1, 5; pl. 2, figs. 1, 2, 5). The other has longer axes of coiling and the chambers of the outer volutions are not so highly inflated (pl. 1, figs. 2–4; pl. 2, figs. 3, 4; pl. 6, fig. 10). The robust specimens are more numerous. The elongate specimens may represent a subspecies of the robust form or they may be specifically distinct. We are proposing a name for the robust form and are referring the more elongate specimens to the same species with question. Several representatives of both kinds are being illustrated. The following specific description is based entirely on the short specimens, but we are giving statistical data taken from the elongate individuals.

Shell short, highly inflated fusiform. Poles bluntly pointed. Lateral slopes slightly concave near poles. Although shell profile is uniform at maturity, position of axis changes slightly with growth of shell. Mature shells of six to seven volutions are 7.5–9.1 mm. long and 4.5–5.8 mm. wide. Form ratios 1.3–1.7. Inner two to three volutions tightly coiled and their poles are bluntly pointed. Lateral slopes of some inner volutions slightly concave. In fourth and fifth volutions chambers highly inflated and septa widely spaced. Outer one or one and a half volutions of mature shells have somewhat lower chambers and somewhat more closely spaced septa than those of fourth and fifth volutions. Average form ratios of first to sixth volutions of three specimens 1.7, 2.0, 1.8, 1.5, and 1.6, respectively.

Proloculus large; its outside diameter

TABLE OF MEASUREMENTS OF *Pseudoschwagerina dallmusi* [SHORT FORM]
(in millimeters)

TABLE OF MEASUREMENTS OF *Pseudoschwagerina dallmusi* [SHORT FORM]
(in millimeters)
(Specimens 1, 2, 4, 5 are illustrated by pl. 2, figs. 1, 2, 5, and pl. 1, fig. 1, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	Thickness of spirotheca 0	1	2	3	4	5	6
1	9.09	5.59	6	.315	.079	.193	.287	.700	1.048	.443	.030	.028	.040	.063	.068	.075	.105
2	—	4.53	5½	.221	.077	.128	.186	.641	.990	.408	.037	.023	.035	.047	.058	.070	.081
3	—	5.83	6	.233	.104	.128	.186	.855	1.015	.559	—	—	—	.037	.056	.084	.093
4	8.28	5.59	6	—	—	.086	.221	.815	1.048	.745	—	—	—	.037	.040	.077	.116
5	8.62	5.59	6½	.179	.070	.109	.237	.808	.908	.512	—	.026	.039	.058	.047	.068	.112
6	7.46	5.75	5	.300	.091	.200	.932	.979	.606	—	.042	.026	.044	.047	.075	.116	—
7	—	5.36	5	.350	.114	.186	.338	.885	.932	—	.047	—	—	—	—	—	—

Specimen	L.	W.	No. vols.	Diam. prol.	Form ratio of volutions 1	2	3	4	5	6	Septal count 1	2	3	4	5	6
1	9.09	5.59	6	.315	1.8	2.0	2.4	2.1	1.7	—	—	—	—	—	—	—
2	—	4.53	5½	.221	—	—	—	—	—	—	13	18	21	22	27	30
3	—	5.83	6	.233	—	—	—	—	—	—	13	20	21	24	18	28
4	8.28	5.59	6	—	—	—	—	—	—	—	—	—	—	—	—	—
5	8.62	5.59	6½	.179	1.5	2.0	2.1	2.0	1.5	1.6	—	—	—	—	—	—
6	7.46	5.57	5	.300	1.7	2.0	1.4	1.2	1.3	—	—	—	—	—	—	—
7	—	5.36	5	.350	—	—	—	—	—	—	13	19	20	16	26	—

TABLE OF MEASUREMENTS OF *Pseudoschwagerina dallmusi* [LONG FORM]
(in millimeters)
(Specimens 1–5 are illustrated by pl. 2, fig. 3; pl. 1, figs. 3, 2; pl. 2 fig. 4; and pl. 6 fig. 10, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	7	Thickness of spirotheca 1	2	3	4	5	6	7
1	9.80	5.59	7	.303	.093	.117	.151	.326	.629	.734	.594	.023	.033	.042	.065	.061	.075	.093
2	9.56	5.47	7	—	.088	.116	.191	.466	.722	.851	.478	—	.026	.037	.079	.082	.117	.105
3	8.28	4.66	6½	.280	.084	.135	.158	.324	.661	.540	.431	.021	.033	.044	.075	.084	.105	.100
4	—	5.59	6	.245	.093	.117	.209	.582	.804	.664	—	.021	.026	.044	.056	.061	.091	—
5	10.95	5.06	6½	.273	.081	.128	.209	.510	.613	.424	—	.026	.028	.051	.058	.084	.102	—

Specimen	L.	W.	No. vols.	Diam. prol.	Form ratio of volutions 1	2	3	4	5	6	Septal count 1	2	3	4	5	6
1	9.80	5.59	7	.303	2.9	2.5	2.5	2.5	2.3	—	—	—	—	—	—	—
2	9.56	5.47	7	—	1.1	1.5	1.9	2.0	1.7	1.7	—	—	—	—	—	—
3	8.28	4.66	6½	.280	1.6	1.8	1.9	1.6	1.8	1.7	—	—	—	—	—	—
4	—	5.59	6	.245	—	—	—	—	—	—	12	17	18	18	19	25
5	10.95	5.06	6½	.273	2.1	2.0	2.0	2.2	2.2	2.1	—	—	—	—	—	—

measures 180–350 microns, averaging 266 microns for six specimens. Heights of chambers in first to seventh volutions of seven specimens average about 87, 147, 341, 812, 935, and 533 microns, respectively. Chambers of about same height throughout length of shell. Heights of first to sixth volutions of holotype about 79, 193, 287, 700, 1048, and 443 microns, respectively. Septa closely spaced in inner volutions, widely spaced in fourth and fifth volutions, and somewhat more closely spaced in outer volutions. Septa fluted throughout length of shell, but fluting seems to be irregularly developed, probably due largely to irregular attitude of septa. In general, septa tend to curve anteriorly. Most of them are irregular in vertical section. Many septa are strongly sinuous in vertical sections. Fluting forms closed chamberlets in lower half to fourth of chambers. Tangential sections reveal transverse paths connecting adjacent chambers, as are found in *Parafusulina*. Cuneculi have not been previously reported in *Pseudoschwagerina*. It should, however, be stressed that published tangential sections of *Pseudoschwagerina* are indeed rare, and the presence or absence of cuneculi in most previously described forms of the genus cannot be verified from available information. A restudy of the original or topotype material of previously described forms may demonstrate that cuneculi are common rather than rare in *Pseudoschwagerina*. The presence of cuneculi in *P. dallmusi* may indicate that this form is highly advanced. Septal pores exceedingly abundant throughout length of shell but most easily observed in outer volutions. Septal counts of first to sixth volutions of one specimen 13, 18, 21, 22, 27, and 30, respectively.

Tunnel very low and moderately wide. Tunnel is difficult to determine in outer volutions because septa are widely spaced and bordering chomata absent. Tunnel angles of first to third volutions of a typical specimen about 14, 15, and 22 degrees, respectively. Chomata distinct in inner volutions; they are narrow and have almost identical slopes on both sides.

Spirotheca rather thin in inner four or five volutions, but increases in thickness sharply in outer volutions of mature shells. In some specimens fourth volution has slightly thinner spirotheca than preceding volution. Thicknesses of spirotheca in first to seventh volutions of a typical specimen 26, 39, 58, 47, 68, and 112 microns, respectively. Spirotheca thickest immediately over tunnel, and decreases in thickness gradually toward poles.

Remarks.—Pseudoschwagerina dallmusi seems to be a typical representative of the genus. It resembles closely several previously described species, including the genotype, *P. uddeni* (Beede and Kniker), *P. robusta* (Meek), *P. roeseleri* Thompson and Hazzard, *P. arta* Thompson and Hazzard, and *P. kozlowskii* Dunbar and Newell. Of these forms, *P. dallmusi* resembles most closely *P. uddeni*, *P. robusta*, and *P. roeseleri*. The holotype of *P. uddeni* is more highly elongate than our specimens, its proloculus is smaller than that of most of the individuals we are studying, and its septa seem to be more highly fluted than those of our specimens. Otherwise, the type specimens of *P. dallmusi* appear to be very closely similar to the holotype of *P. uddeni*.

The vertical ranges of many species of *Pseudoschwagerina* have not been determined, and it is possible that some of them are long. The close similarity of *P. dallmusi* to forms from the McCloud limestone and Bird Springs formation of California and the Hueco limestone and the type Wolfcamp section of west Texas suggest that the collection under consideration is of about the

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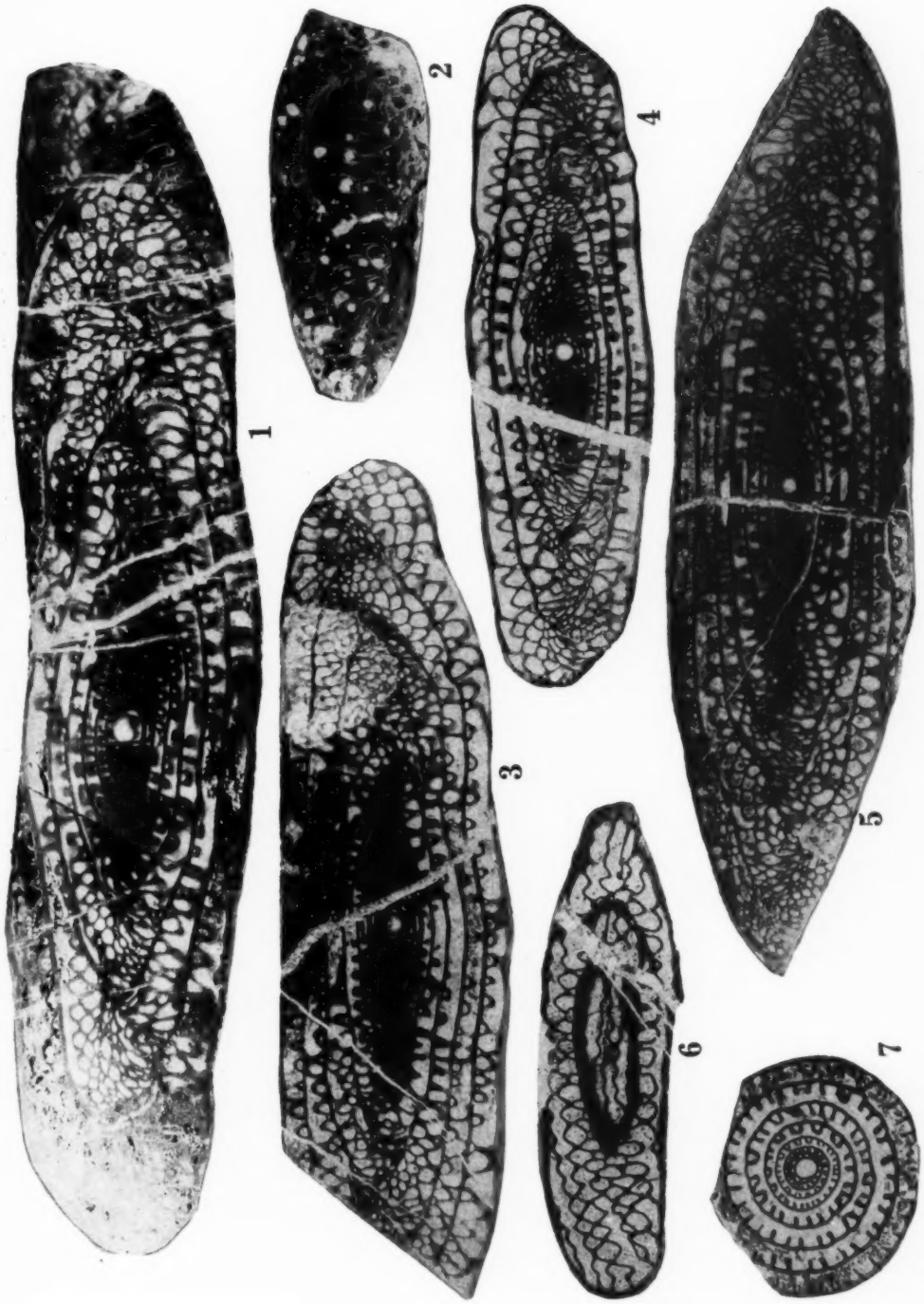
EXPLANATION OF PLATE 3

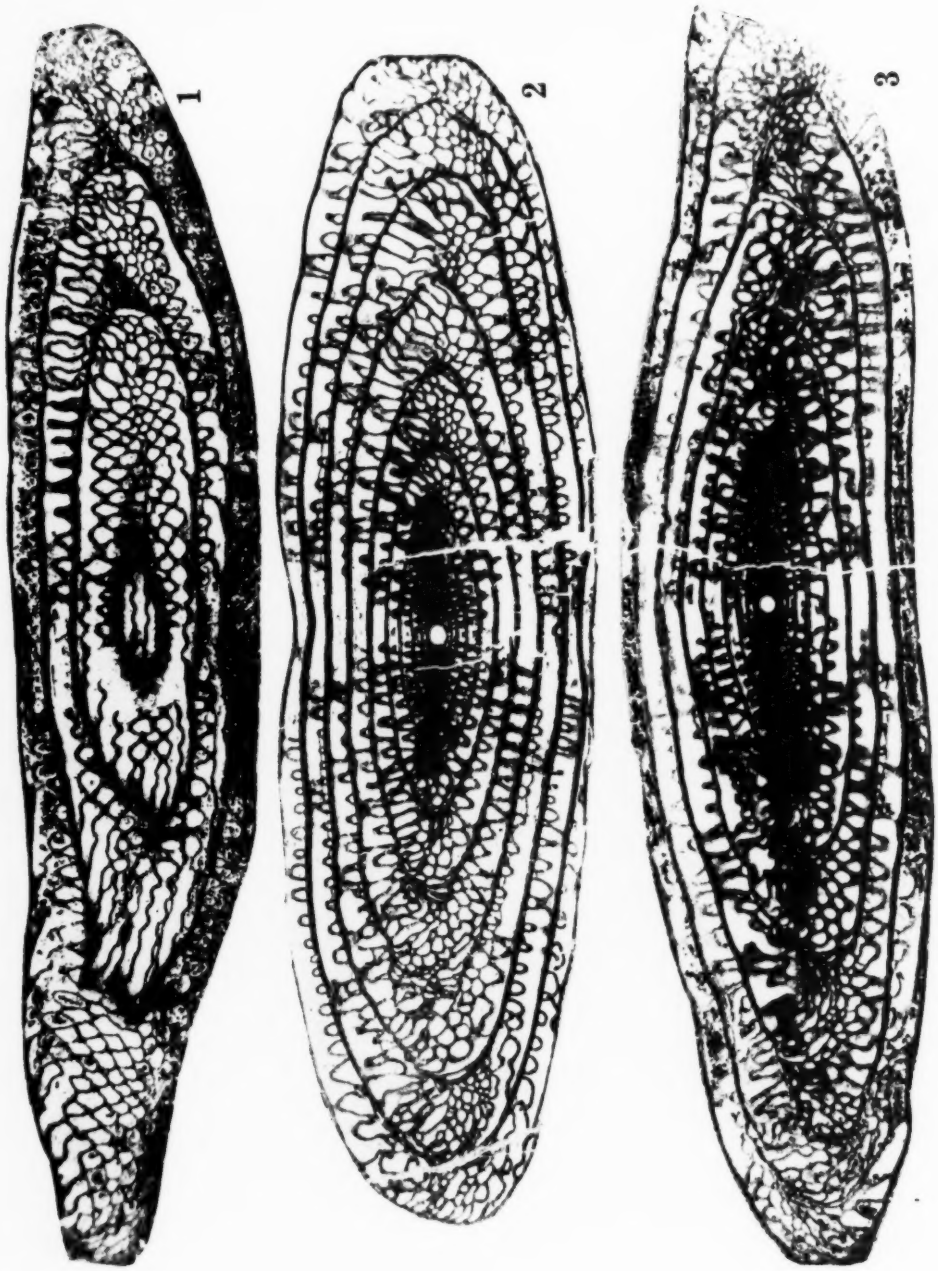
All illustrations on this plate are unretouched photographs, ×10.

FIGS. *1, 2—Parafusulina nancei* Thompson and Miller, n. sp. Axial section of holotype (fig. *1*), and tangential section of paratype (fig. *2*). Collection 30473, Venezuela. (See also plates 5, 6.) (p. 16)

3–7—Parafusulina durhami Thompson and Miller, n. sp. Axial section of holotype (fig. *3*); and axial (figs. *4, 5*), tangential (fig. *6*), and sagittal (fig. *7*) sections of paratypes. Collection 19063, Colombia. (See also plate 5.) (p. 15)



Thompson and Miller, Permian Fossils from Maracaibo Region



Thompson and Miller, Permian Fossils from Maracaibo Region

same age as those formations. It was observed in the field that Collection 9186 seemed to be stratigraphically higher than Collection 9185 which contains *Perrinites hilli* (Smith)?. *P. hilli?* is believed to be Leonardian in age. Therefore, it seems that either the collection we are studying is from faulted or overturned strata or that *Pseudoschwagerina* has a higher stratigraphic range in America than previously known.

The holotype and paratypes of *Pseudoschwagerina dallmusi* resemble in certain respects the elongate associated specimens we are illustrating. However, several points of difference can be observed by comparing the accompanying statistical data. For example, the type specimens are more highly inflated in the outer chambers, the shell is shorter and therefore has a smaller form ratio for corresponding volutions, and the early tightly coiled part of the shell has fewer volutions. In the elongate specimens the spirotheca increases in thickness more or less uniformly with the growth of the individual; but in the type specimens the thickness of the spirotheca increases to the third volution, decreases in parts of the fourth volution, and increases rapidly near the end of the fifth volution.

This species is named in honor of Mr. K. F. Dallmus, who sent us part of the South American fusulinids on which this report is based.

Occurrence.—Pseudoschwagerina dallmusi is very abundant in Collection 9186 where it is associated with numerous specimens of *Schubertella australis*, n. sp. This collection came from the north side of Quebrada Manaure, about 4.5 kilometers east of the village of Manaure, Departamento de Magdalena, Colombia.

SCHWAGERINA? HEDBERGI Thompson and Miller, n. sp.
Plate 7, figures 1–7

Shell large, inflated fusiform, with straight axis of coiling, sharply pointed poles, and convex lateral slopes. Our largest specimen, the holotype, which consists of eight volutions, is 10.95 mm. long and 4.66 mm. wide. Form ratio of same specimen is 2.3. Shape of shell changes with growth of individual from slightly elongate in inner two volutions, inflated in third to fifth volutions, more elongate in sixth volution, and inflated in outer volution. Form ratios of first to seventh volutions of holotype 2.6, 2.6, 2.2, 1.9, 2.1, 2.2, and 2.0, respectively. Average form ratios of first to sixth volutions of four specimens, including holotype, 2.2, 2.3, 2.2, 2.1, 2.2, and 2.3, respectively.

Proloculus small, spherical. Its outside diameter 123–230 microns, averaging 188 microns for six specimens. Shell expands regularly throughout growth of individual. Average heights of chambers in first to eighth volutions of six specimens 61, 93, 164, 238, 292, 360, 385, and 501 microns, respectively. Chambers increase in height slightly from center of shell toward poles.

Spirotheca thin in inner volutions, thick in outer volutions, of about same thickness across central three-fourths of shell. Average thicknesses of spirotheca in second to eighth volutions of seven specimens 26, 36, 55, 74, 93, 98, and 107 microns, respectively. Proloculus wall of one specimen 33 microns thick. Spirotheca of first volution very thin but not measured accurately.

Septa narrowly and highly fluted throughout length of shell. Closed chamberlets extend almost to tops of chambers. Pycnotheca of moderate thickness. Average septal counts of first to seventh volutions of three specimens 12, 21, 26, 30, 35, 40, and 41, respectively.

Tunnel narrow, path irregular, of variable width. Tunnel angles of second to eighth volutions of holotype 20, 26, 27, 19, 23, and 20 degrees, respectively. Chomata very narrow in first two volutions, not recognizable in outer volutions. Axial fillings very thick; completely fill chambers in wide belt along axis of coiling of all parts of shell except outer volution.

EXPLANATION OF PLATE 4

All illustrations on this plate are unretouched photographs, ×10.

FIGS. *1–3—Parafusulina trumpyi* Thompson and Miller, n. sp. Tangential (fig. *1*) and axial (fig. *2*) sections of paratypes, and axial section of holotype (fig. *3*). Collection 19061, Colombia. (See also plate 5.) (p. 18)

TABLE OF MEASUREMENTS OF *Schwagerina? hedbergi*
(in millimeters)
(Specimens 2–7 are illustrated as pl. 7, figs. 1, 3, 2, 5, 6, 4, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	7	8	Thickness of spirotheca 2	3	4	5	6	7	8
1	7.92	3.15	7	.123	.065	.098	.214	.209	.317	.326	.408	—	—	.037	.061	.075	.075	.086	—
2	10.90	3.73	6½	.191	.063	.112	.151	.263	.287	.396	—	—	—	.033	.056	.065	.086	.093	—
3	5.60	2.54	6½	.179	.051	.065	.128	.233	.280	.338	—	—	—	—	.047	.070	.111	—	—
4	10.95	4.66	8	.230	.072	.098	.191	.233	.326	.373	.373	.501	.026	.051	.063	.075	.105	.105	.107
5	—	3.50	7	—	—	—	—	—	—	—	—	—	—	.028	.051	.088	.093	.117	—
6	—	3.38	7	.191	.051	.079	.135	.245	.265	.373	.373	—	—	.030	.044	.072	.093	.088	—
7	—	2.33	6	.214	.065	.107	.168	.245	.280	.350	—	—	.026	.035	.061	.072	.091	—	—
8	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Specimen	L.	W.	No. vols.	Diam. prol.	Form ratio of volutions 1	2	3	4	5	6	7	Septal count 1	2	3	4	5	6	7	Tunnel angle (in degrees) 2	3	4	5	6	7	8
1	7.92	3.15	7	.123	2.2	2.1	1.9	2.0	2.0	2.3	—	—	—	—	—	—	—	—	—	22	20	21	23	23	—
2	10.90	3.73	6½	.191	2.3	2.2	2.1	2.1	2.2	2.4	—	—	—	—	—	—	—	—	—	—	—	20	25	26	—
3	5.60	2.54	6½	.179	1.8	2.5	2.5	2.4	2.3	2.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	10.95	4.66	8	.230	2.6	2.6	2.2	1.9	2.1	2.2	2.0	—	—	—	—	—	—	—	20	26	27	19	26	23	20
5	—	3.50	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	3.38	7	.191	—	—	—	—	—	—	—	15	21	23	27	34	35	40	—	—	—	—	—	—	—
7	—	2.33	6	.214	—	—	—	—	—	—	—	12	20	28	34	36	46	—	—	—	—	—	—	—	—
8	—	—	7	—	—	—	—	—	—	—	—	11	22	27	29	35	39	42	—	—	—	—	—	—	—

Remarks.—*Schwagerina? hedbergi* resembles *S. ahlfeldi* Dunbar and Newell from the Lake Titicaca area of Bolivia more closely than any previously described South American fusulinids. However, these two forms can be distinguished without difficulty for the former has a much larger shell and a thicker spirotheca, and it is more loosely coiled. Generically, these two species are closely similar, but we are not certain that they are congeneric with the genotype of *Schwagerina, S. princeps* (Ehrenberg). These forms belong to a group of fusulinids that occur in rocks ranging in age from upper Wolfcampian to almost the top of the Permian. The form from the La Vainella limestone of Chiapas that Thompson and Miller (1944) described as *Schwagerina* sp. B belongs to this same group of fusulinids. Somewhat similar species occur associated with the "Tethys" fusulinid faunas of northwestern North America, and many fusulinids of this general type occur in the Tethys faunas of the eastern hemisphere. All of them generally are referred to *Schwagerina*. They may, however, be more closely related to *Nagatoella* than to *Schwagerina*.

The specific name is given in honor of Dr. H. D. Hedberg, who has contributed greatly to our acknowledge of the geology of the Maracaibo basin.

Occurrence.—*Schwagerina hedbergi* is abundant in Collection 5006 which came from a bluish-gray highly crinoidal limestone in Quebrada Manaure, along the road from La Paz to Manaure and about 6 kilometers east of La Paz, Departamento de Magdalena, Colombia. Only one species of fusulinids was found in this collection.

PARAFUSULINA DURHAMI Thompson and Miller, n. sp.

Plate 3, figures 3–7; Plate 5, figures 9, 11, 12

Shell large, elongate subcylindrical; with irregular axis of coiling, pointed poles, and irregular lateral slopes. Shells of seven and a half to eight and a half volutions are 13.0–13.8 mm. long, 3.2–3.8 mm. wide, and have form ratios of 3.9–4.5. Inner volutions uniform in profile. Shell from fifth volution to maturity has somewhat irregular profile. Average form ratios of first to seventh volutions of four specimens 2.2, 2.8, 3.1, 3.6, 3.9, 4.3, and 4.3, respectively.

Proloculus of moderate size. Outside diameter 250–408 microns, averaging 333 microns for eight specimens. Shell tightly coiled. Chambers increase in height gradually and uniformly for first nine volutions. Chambers of outer volution of specimens of nine volutions slightly lower than that of preceding volution. Average heights of first to ninth volutions of nine specimens 68, 98, 125, 179, 257, 268, 307, and 324 microns, respectively.

Spirotheca thin and of about same thickness throughout length of shell, except in extreme polar regions where spirotheca is very thin. Spirotheca decreases in thickness slightly in last volution of most specimens. Thicknesses of spirotheca in second to eighth volutions of holotype 27, 30, 35, 46, 51, 65, and 54 microns, respectively. Average thicknesses of spirotheca in first to eighth volutions of nine specimens, including holotype, 26, 32, 36, 43, 52, 58, 66, and 65 microns, respectively. As in the great majority of fusulinids, the spirotheca of last volution of most mature and submature specimens is slightly thinner than in the penultimate volution. In submature specimens, the spirotheca of the ultimate volution is thinner than that of corresponding parts of the shell of larger individuals, indicating that the spirotheca "grew" after later chambers were added.

Septa highly and narrowly fluted. Cunecuuli developed throughout most of shell. Average septal counts of first to eighth volutions of three specimens 12, 26, 27, 27, 31, 32, 41, and 44, respectively.

Tunnel broad, slightly less than half as high as chambers. Tunnel angles of third to seventh volutions of holotypes 36, 41, 41, 47, and 58 degrees, respectively. Average tunnel angles of second to seventh volutions of six specimens 22, 31, 34, 35, 45, and 56 degrees, respectively. Chomata indistinct in inner three to four volutions, not recognizable in outer volutions. Axial fillings dense and broad in inner four to five volutions, discontinuous in outer volutions.

Remarks.—The small size, more tightly coiled shell, thinner spirotheca, and slightly

more massive axial fillings of *Parafusulina durhami* serve to distinguish it from *P. trumpyi*. *P. durhami* can be distinguished from *P. nancei* by its smaller proloculus, more tightly coiled shell, less extended polar regions, and smaller size for shells of the same number of volutions.

The specific name is given in honor of Dr. J. Wyatt Durham, who collected most of the specimens on which this report is based and kindly sent them to us for study.

Ocurrence.—Parafusulina durhami is exceedingly abundant in Collection 19063, obtained from the hillside on the north side of Quebrada Manaure, about 4.5 kilometers east of the village of Manaure, Departamento de Magdalena, Colombia.

PARAFUSULINA NANCEI Thompson and Miller, n. sp.

Plate 3, figures 1, 2; Plate 5, figures 1–6; Plate 6, figures 1, 2

Shell large, elongate, irregular, subcylindrical, with irregular axis of coiling, bluntly pointed poles, and irregular lateral slopes. One of our largest specimens, the holotype, consists of seven volutions, and it is 15.78 mm. long and 3.73 mm. wide. Form ratios of larger specimens 4.1–4.2. Average form ratios of first to sixth volutions of three specimens 2.4, 3.0, 3.0, 3.1, 3.4, and 4.0, respectively. Axis of coiling irregular for all volutions.

Proloculus large, its outside diameter

TABLE OF MEASUREMENTS OF *Parafusulina durhami*
(in millimeters)
(Specimens 1–3, 5–8 are illustrated by pl. 3, fig. 5; pl. 5, fig. 12; pl. 3, fig. 3; pl. 5, figs. 11, 9; and pl. 3, figs. 7, 4, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	7	8	9
1	13.75	3.50	8	.291	.062	.111	.116	.163	.221	.233	.249	.268	—
2	—	2.32	6	.408	.046	.093	.107	.144	.252	.233	—	—	—
3	12.96	3.24	7½	.362	.050	.086	.100	.163	.225	.263	.280	.326	—
4	—	2.92	7	.362	.070	.102	.109	.177	.254	.270	.338	—	—
5	—	3.26	8½	.250	.054	.082	.140	.158	.200	.233	.312	.350	.186
6	—	3.77	8	—	—	.104	.168	.209	.310	.322	.350	.350	—
7	—	3.30	7	.310	.070	.084	.109	.221	.280	.303	.315	—	—
8	9.52	2.59	6	.326	.107	.105	.150	.182	.268	.312	—	—	—
9	6.52	1.88	5	.354	.084	.128	.126	.191	.303	—	—	—	—

Specimen	Thickness of spirotheca 1	2	3	4	5	6	7	8	9	Form ratio of volutions 1	2	3	4	5	6	7
1	—	.027	.030	.035	.046	.051	.065	.054	—	2.5	3.0	3.3	3.7	3.8	4.5	4.5
2	.014	.035	.028	.042	.046	.063	—	—	—	2.0	2.4	2.6	3.2	—	—	—
3	—	—	—	.043	.044	.063	.065	.079	—	2.0	3.2	3.2	4.0	4.0	4.0	4.1
4	—	—	—	.050	.051	.050	.077	—	—	—	—	—	—	—	—	—
5	.035	.035	.037	.037	.047	.051	.070	.072	.051	—	—	—	—	—	—	—
6	.028	.030	.040	.044	.056	.056	.065	.056	—	—	—	—	—	—	—	—
7	.026	.033	.035	.042	.043	.061	.056	—	—	—	—	—	—	—	—	—
8	—	—	.042	.051	.061	.070	—	—	—	—	—	—	—	—	—	—
9	—	.035	.040	.040	.070	—	—	—	—	2.6	2.7	3.1	3.5	—	—	—

Specimen	Septal count 1	2	3	4	5	6	7	8	Tunnel angle (degrees) 2	3	4	5	6	7
1	—	—	—	—	—	—	—	—	—	36	41	41	47	53
2	—	—	—	—	—	—	—	—	22	22	26	27	—	—
3	—	—	—	—	—	—	—	—	—	36	37	40	55	60
4	—	—	—	—	—	—	—	—	23	35	39	39	—	—
5	12	25	25	27	31	33	38	46	—	—	—	—	—	—
6	14	25	26	28	31	33	43	42	—	—	—	—	—	—
7	10	29	30	27	30	31	42	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—	28	30	32	33	—
9	—	—	—	—	—	—	—	—	20	32	30	30	—	—

TABLE OF MEASUREMENTS OF *Parafusulina nancei*
(in millimeters)
(Specimens 1–8 are illustrated by pl. 3, fig. 1; pl. 5, figs. 2, 1, 3; pl. 6, fig. 2; and pl. 5, figs. 5, 6, 4, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6	7
1	15.78	3.73	7	.360	.121	.131	.182	.219	.296	.314	.420	—	—	.035	.035	.051	.061	.081	.125
2	10.90	2.66	6	.350	.089	.116	.163	.217	.256	.350	—	—	—	.035	.037	.044	.058	.077	—
3	12.80	2.80	5½	.490	.088	.124	.158	.233	.312	.395	—	.035	.030	.035	.040	.051	.063	—	—
4	—	2.75	6	.428	.077	.128	.158	.202	.326	.350	—	.030	—	.028	.035	.050	.051	.070	—
5	—	2.80	6	.412	.077	.114	.142	.209	.340	.384	—	.039	—	—	.044	.056	.056	.079	—
6	—	3.00	6	.466	.100	.153	.223	.279	.326	.372	—	.044	.026	.037	.037	.058	.063	—	—
7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	—	2.45	5	.466	.084	.100	.172	.242	.310	—	—	.035	.028	.040	.042	.056	.058	—	—

Specimen	L.	W.	No. vols.	Diam. prol.	Form ratio of volutions 1	2	3	4	5	6	Septal count 1	2	3	4	5	6	Tun. ang. (deg.) 2	3	4	5	6
1	15.78	3.73	7	.360	2.9	3.0	2.9	3.1	3.3	4.0	—	—	—	—	—	—	37	28	32	32	45
2	10.90	2.66	6	.350	2.6	2.8	3.1	3.2	3.5	—	—	—	—	—	—	—	—	—	33	36	41
3	12.80	2.80	5½	.490	2.2	3.1	3.0	3.0	3.4	—	—	—	—	—	—	—	—	32	38	36	—
4	—	2.75	6	.428	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	41	40
5	—	2.80	6	.412	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	3.00	6	.466	—	—	—	—	—	—	16	30	34	36	39	43	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—	—	17	30	35	33	—	—	—	—	—	—	—
8	—	2.45	5	.466	—	—	—	—	—	—	16	24	31	32	35	—	—	—	—	—	—

measures 350–466 microns, averaging 437 microns for ten specimens. Proloculus of some specimens spherical in shape, that of a few subspherical. Short inverted funnel-like neck in proloculus aperture. Heights of chambers increase almost uniformly during first four volutions, gradually in fifth and sixth volutions, and rapidly in seventh volution. Heights of chambers above tunnel in first to seventh volutions of holotype 121, 131, 182, 219, 296, 314, and 420 microns, respectively. Average heights of chambers in first to sixth volutions of seven specimens, including holotype, 91, 124, 171, 230, 310, 361, and 421 microns, respectively. Chambers slightly higher in polar regions than above tunnel in inner three to four volutions, much higher in polar regions than above tunnel in outer volutions.

Spirotheca thin, structure typical of genus. Proloculus wall dense and uniform in texture, slightly thicker than spirotheca of first chamber. Proloculus wall averages about 36 microns for seven specimens. Average thicknesses of spirotheca of first to seventh volution of seven specimens 28, 35, 38, 52, 59, 77, and 125 microns, respectively. It is evident that the spirotheca increases in thickness rapidly from sixth to seventh volutions. Spirotheca decreases in thickness gradually and almost uniformly from center of shell to poles. Inasmuch as the spirotheca of the last volution of our largest specimens is so much thicker than that of the preceding volution, it is possible that none of our specimens is mature.

Septa rather closely spaced, highly and narrowly fluted throughout length of shell. Cuneculi developed in at least outer volutions. Septal counts of first to sixth volutions of a typical section 16, 30, 34, 36, 39, and 43, respectively.

Tunnel low and irregularly developed. Rudiments of septa left in center of tunnel in some volutions. Tunnel path irregular. Tunnel angle variable. Average tunnel angles of second to sixth volutions of four specimens 37, 30, 34, 36, and 42 degrees respectively. Axial deposits fill most chambers to edges of tunnel in inner five volutions, thin and confined to base of chambers in outer volutions.

Remarks.—The large proloculus, expanded outer volutions, more closely spaced septa, and thick spirotheca of the outer volutions serve to distinguish *Parafusulina nancei* from *P. durhami* and *P. trumpyi*.

Parafusulina nancei is the only fusulinid we have from Venezuela that was collected *in situ*. A number of other fusulinids are here illustrated from Venezuela, but all of them are from pebbles of lower Mesozoic conglomerates. Insofar as we can tell, the only other fusulinid illustrated from unreworked bedrock in Venezuela is the form from the type section of the Palmarito formation that Gerth (1931) figured as *Fusulina* cf. *verneuili* Möller. Gerth's specimens may possibly be conspecific with the types of *P. durhami*.

This species is named in honor of Mr. J. W. Nance, who collected the sample that yielded its type specimens.

Occurrence.—*Parafusulina nancei* is abundant in a gray limestone exposed in the gorge of Río Boconó, below the village of Boconó, Barinas, Venezuela. Many of the specimens are distorted and numerous calcite veins and small faults intersect them.

PARAFUSULINA TRUMPYI Thompson and Miller, n. sp.
Plate 4, figures 1–3; Plate 5, figures 7, 8, 10

Shell large, elongate fusiform, with irregular to broadly curving axis of coiling,

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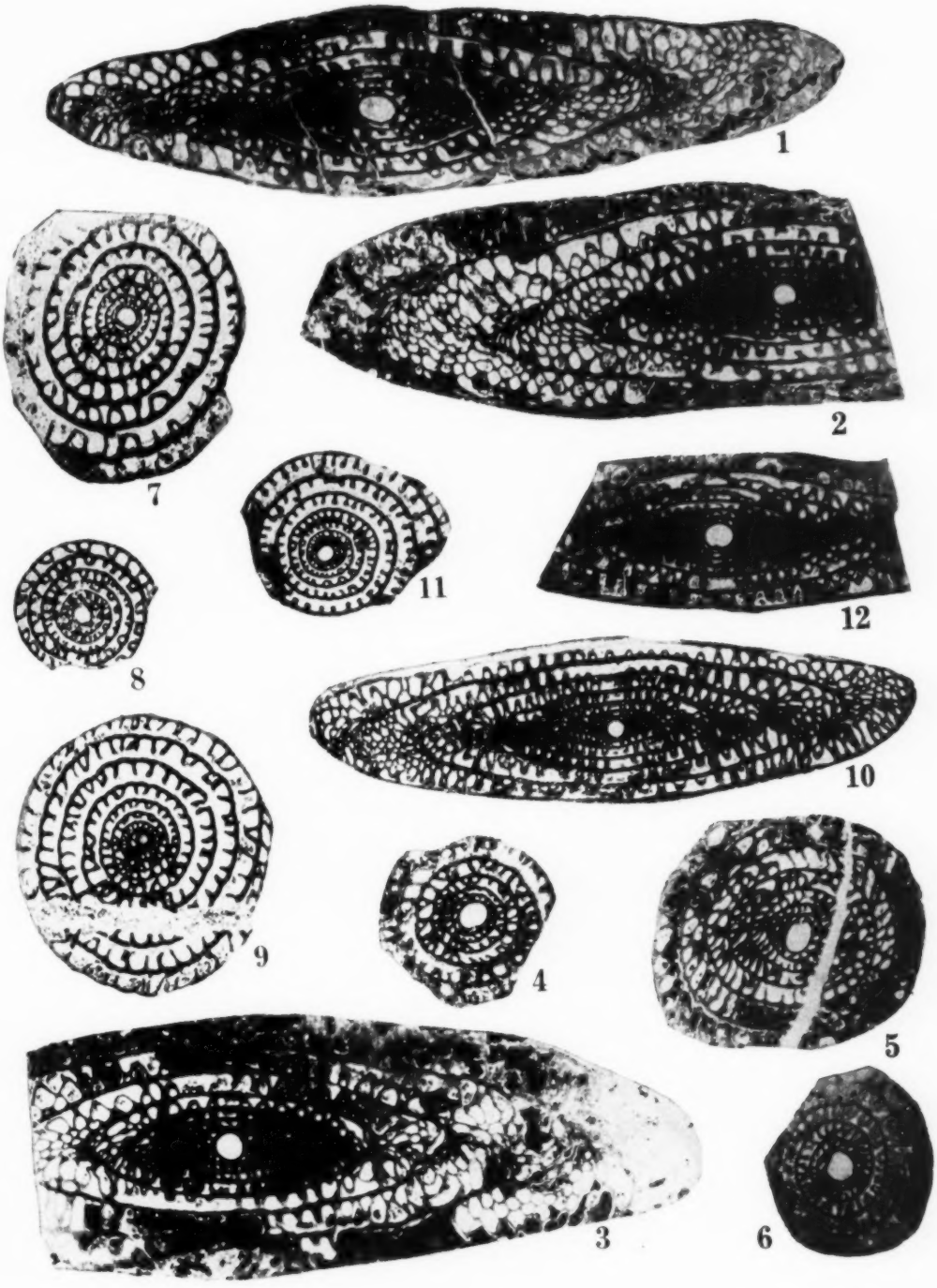
EXPLANATION OF PLATE 5

All illustrations on this plate are unretouched photographs. ×10.

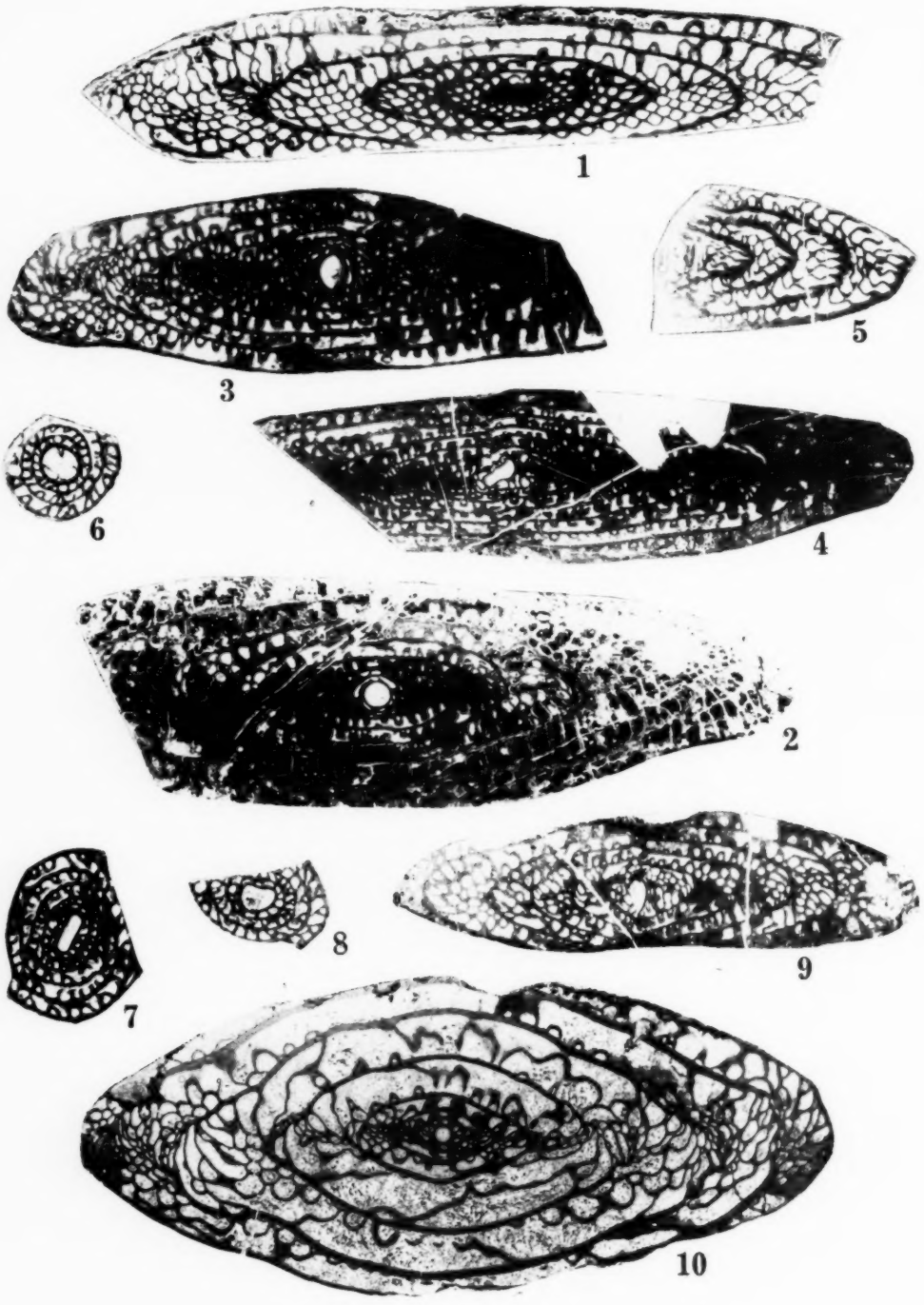
FIGS. *1–6*—*Parafusulina nancei* Thompson and Miller, n. sp. Axial (figs. *1–3*) and sagittal (figs. *4–6*) sections of paratypes. Collection 30473, Venezuela. (See also plates 3, 6.) (p. 16)

7, 8, 10—*Parafusulina trumpyi* Thompson and Miller, n. sp. Sagittal (figs. *7, 8*) and axial (fig. *10*) sections of paratypes. Collection 19061, Colombia. (See also plate 4.) (p. 18)

9, 11, 12—*Parafusulina durhami* Thompson and Miller, n. sp. Sagittal (figs. *9, 11*) and axial (fig. *12*) sections of paratypes. Collection 19063, Colombia. (See also plate 3.) (p. 15)



Thompson and Miller, Permian Fossils from Maracaibo Region



Thompson and Miller, Permian Fossils from Maracaibo Region

convex to slightly concave lateral slopes, and pointed poles. Shells of eight and a half to nine and a half volutions are 15.6–18.2 mm. long and 3.5–4.7 mm. wide. Form ratio 3.5–4.7. In some, axis of coiling is straight. In most, axis is curving to irregular. Few thin sections intersect axis throughout length of shell. Poles of inner five volutions sharply pointed, those of outer volutions bluntly pointed to narrowly rounded. Lateral slopes convex in inner five volutions and irregular in outer volutions. Length of shell increases uniformly with increase in width for first seven volutions, but it increases more rapidly than increase of width in outer volutions. Form ratios of first to eighth volutions of holotype 2.5, 3.2, 3.6, 3.7, 3.6, 3.5, 4.0, and 4.8, respectively.

Proloculus large, spherical. Its outside diameter measures 275–325 microns, averaging 306 microns for seven specimens. Shell expands uniformly in first seven volutions, becoming slightly more tightly coiled in outer two to three volutions. Average heights of first to ninth volutions in seven specimens 65, 90, 143, 193, 227, 276, 339, 332, and 321 microns, respectively.

Septa closely spaced, narrowly and highly fluted throughout length of shell in all volutions. Cuneculi developed seemingly throughout length of outer volutions, not definitely recognized in inner volutions. Excavation of cuneculi not as pronounced as in some late forms of the genus in the middle Guadalupian of North America. Septal counts of first to sixth volutions of one sagittal section 16, 23, 25, 30, 31, and 38, respectively.

Spirotheca relatively thin. Its average thicknesses in first to tenth volutions of six specimens 24, 32, 42, 60, 67, 83, 95, 96, 85, and 63 microns, respectively. As these average figures and the accompanying statistical data indicate, the spirotheca of the outer volutions of large and most smaller specimens is slightly thinner than that of immediately preceding volutions. Also, in specimens of seven or eight volutions the spirotheca of the outer volution is not as thick as that in corresponding volutions of larger specimens. Phrenothecae occur in outer volutions of some specimens.

Tunnel broad and about half as high as chambers. Average tunnel angles of second to ninth volutions in three specimens 28, 34, 40, 35, 37, 51, 52, and 46 degrees, respectively. Distinct chomata not recognized in any part of shell. Axial fillings dense in immediate axial region of inner four volutions, discontinuous in outer volutions.

Remarks.—Specimens of *Parafusulina trumpyi* are the most common of any species of this genus in our collections from Colombia and Venezuela. It is the only fusulinid found in Collection 12087 and Collection 19061. Both of these collections are from float obtained from approximately the same locality in Río Molino, about 6 kilometers upstream from the village of Molino, Departamento de Magdalena, Colombia. Collection 12087 is entirely chert and all specimens are silicified. Collection 19061 is a dark gray to black highly silicified limestone and many of the specimens are silicified. However, many specimens of Collection 19061 are not silicified and their preservation is essentially perfect. The above description is based almost entirely on specimens of the latter collection.

Parafusulina trumpyi is the largest fusulinid known from South America. It is closely similar in size to *P. nancei*. It can be distinguished from *P. durhami* by its slightly larger size for specimens of the same number of volutions, more loosely coiled shell,

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EXPLANATION OF PLATE 6

All illustrations on this plate are unretouched photographs, ×10.

FIGS. *1, 2*—*Parafusulina nancei* Thompson and Miller, n. sp. Tangential (fig. *1*) and oblique axial (fig. *2*) sections of paratypes. Collection 30473, Venezuela. (See also plates 3, 5.) (p. 16)

3–9—*Parafusulina?* sp. D. Axial (figs. *3, 4*), tangential (fig. *5*—showing what may be multiple tunnels), sagittal (figs. *6–8*), and oblique axial (fig. *9*) sections. Collection 35164, Venezuela. (p. 22)

10—*Pseudoschwagerina dallmusi* Thompson and Miller?, n. sp. Axial section of an exceptionally long specimen. Collection 9186, Colombia. (See also plates, 1, 2.) (p. 10)

TABLE OF MEASUREMENTS OF *Parafusulina trumpyi*
(in millimeters)
(Specimens 1–4, 7 are illustrated by pl. 4, fig. 2; pl. 5, fig. 7; pl. 4, fig. 3; and pl. 5, figs. 8, 10, respectively.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions									Thickness of spirotheca								
					1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10
1	15.60	4.43	9½	.302	.070	.088	.123	.195	.233	.297	.328	.350	.372	.028	.035	.040	.065	.086	.086	.100	.104	.093	.063
2	—	3.96	8	.326	.056	.084	.139	.201	.244	.315	.373	—	—	.019	.030	.044	.063	.067	.086	.070	.072	—	—
3	18.17	3.84	8½	.279	.063	.081	.109	.177	.252	.305	.326	.338	.278	.024	.028	.044	.056	.068	.093	.116	.109	.077	—
4	—	2.04	6	.309	.070	.100	.104	.186	.198	.233	—	—	—	—	—	—	—	—	—	—	—	—	—
5	—	4.28	9	.322	.086	.108	.135	.209	.216	.303	.428	.303	.312	.023	.033	.037	.061	.063	.075	.112	.100	.086	—
6	—	2.56	6½	.305	.051	.091	.139	.223	.231	.256	—	—	—	.027	.035	.043	.053	.061	.086	—	—	—	—
7	8.74	2.56	6½	.300	.058	.075	.151	.163	.215	.221	.245	—	—	—	—	—	—	—	.075	.075	—	—	—

Specimen	Form ratio of volutions									Septal count						Tunnel angle (degrees)							
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	2	3	4	5	6	7	8	9
1	2.7	3.3	3.5	3.5	3.6	3.8	4.0	3.8	3.8	—	—	—	—	—	—	36	36	36	36	39	54	40	46
2	—	—	—	—	—	—	—	—	—	13	22	24	27	26	34	—	—	—	—	—	—	—	—
3	2.5	3.2	3.6	3.7	3.6	3.5	4.0	4.8	—	—	—	—	—	—	—	28	36	50	35	40	49	64	—
4	—	—	—	—	—	—	—	—	—	16	23	25	30	31	38	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	2.7	2.9	3.3	3.2	3.6	3.9	—	—	—	—	—	—	—	—	—	20	30	33	34	32	—	—	—

thicker spirotheca, and less massive axial fillings. From *Parafusulina nancei*, *P. trumpyi* can be distinguished by its smaller proloculus, thinner spirotheca in outer volutions, and more tightly coiled corresponding outer volutions.

Parafusulina trumpyi resembles rather closely *P. sellardsi* Dunbar and Skinner of the Word formation of Texas. However, these two forms can be distinguished specifically by their marked difference in septal counts, the more pointed poles of *P. trumpyi*, the somewhat smaller proloculus of the same species, and the larger size of most mature specimens of *P. sellardsi*. The cuneculi of *P. trumpyi* do not seem to be as well defined as are those of *P. sellardsi*, and it seems probable that *P. trumpyi* is less advanced and came from somewhat older beds than *P. sellardsi*.

This species is named for Mr. D. Trumpy, in recognition of his work on the pre-Cretaceous strata of Colombia.

PARAFUSULINA sp. A
Plate 7, figures 14, 17

From the basal conglomerate of the La Quinta formation about 15.5 kilometers from Trujillo along the San Lazaro-Trujillo road, J. Wyatt Durham secured some pebbles (Collection 19150) that have yielded a considerable number of fusulinids which seem to represent several species. All of them may be referable to the genus *Parafusulina*. Some belong in undescribed species, but we hesitate to propose names for specimens that came from conglomeratic material. Nevertheless, we feel that they should be illustrated.

The forms that are being designated *Parafusulina* sp. A are elongate, irregularly subcylindrical, with a large irregular proloculus that is at least 600 microns in diameter, thin spirotheca throughout the shell, and distinct cuneculi. One proloculus wall is about 47 microns thick. The spirotheca of the first to sixth volutions, respectively, of the same specimen are only 30, 23, 35, 35, 37, and 35 microns thick. The septa are highly and narrowly fluted throughout the shell. The septal counts of the first to sixth volutions of one specimen are 14, 28, 30, 31, 38, and 43, respectively.

TABLE OF MEASUREMENTS OF *Parafusulina?* sp. D
(in millimeters)

(Specimens 1–5 are illustrated by pl. 6, figs. 4, 3, 6, 7, 8, respectively. Double measurements for proloculus are minimum and maximum diameters through center.)

Specimen	L.	W.	No. vols.	Diam. prol.	Height of volutions 1	2	3	4	5	6	7	Thickness of spirotheca 1	2	3	4	5	6	7
1	13.05	2.45	7	.256/.548	.093	.112	.140	.140	.163	.202	.233	—	.035	.044	.042	.042	.047	.061
2	9.32	2.30	6	.419/.582	.088	.139	.163	.151	.221	.245	—	.040	.033	.037	.044	.051	.044	.058	—
3	—	1.80	3½	.536/.582	.107	.163	.202	.209	—	—	—	.040	.023	.037	.040	.047	—	—	—
4	—	1.98	5	.256/.652	.116	.088	.186	.209	.233	—	—	.037	.023	.033	.040	.047	.060	—	—
5	—	1.40	3½	.420/.536	.093	.116	.163	.191	—	—	—	.040	.028	.030	.038	.054	—	—	—

Specimen	L.	W.	No. vols.	Diam. prol.	Form ratio of volutions 1	2	3	4	5	6	7	Septal count 1	2	3	4	5
1	13.05	2.45	7	.256/.548	2.2	3.0	4.0	4.6	4.6	4.8	5.3	—	—	—	—	—
2	9.32	2.30	6	.419/.582	—	—	—	—	—	—	—	—	—	—	—	—
3	—	1.80	3½	.536/.582	—	—	—	—	—	—	—	20	25	30	—	—
4	—	1.98	5	.256/.652	—	—	—	—	—	—	—	15	26	29	32	34
5	—	1.40	3½	.420/.536	—	—	—	—	—	—	—	13	24	26	—	—

PARAFUSULINA sp. B
Plate 7, figures 13, 15

Collection 19150 yielded a number of large specimens that are similar but specifically distinct from those just discussed. They are designated *Parafusulina* sp. B. This form resembles in some respects *Parafusulina nancei* from near Boconó, Barinas, Venezuela, and the two may be conspecific; however, we do not have a sufficient number of oriented sections of the form under consideration to permit satisfactory detailed comparisons.

One of our larger axial sections of seven volutions is elongate subcylindrical in shape and is 6.29 mm. long and 3.02 mm. wide. The axial fillings of this specimen are thin. The proloculus measures about 419 microns in diameter. The heights of the first to seventh volutions are 72, 89, 149, 180, 233, 233, and 305 microns, respectively. The spirotheca of the second to seventh volutions, respectively, of the same specimen are about 33, 47, 65, 70, 65, and 82 microns thick.

PARAFUSULINA? sp. C
Plate 7, figure 16

Rare specimens of a small fusulinid have been obtained from Collection 19150 of pebbles from the basal conglomerate of the Triassic? La Quinta red beds along the road between San Lazaro and Trujillo and about 15.5 kilometers from Trujillo. We are designating these specimens *Parafusulina?* sp. C and are illustrating one section.

This form has a minute proloculus, tightly coiled shell, no observable tunnel, distinct cuneculi, broad but not thick axial fillings, sharply pointed poles, and slightly inflated central area. In one specimen the outside diameter of the proloculus measures about 49 microns, and the heights of the chambers in the first to ninth volutions are about 23, 33, 35, 70, 89, 140, 163, 168, and 175 microns respectively. This specimen consists of nine volutions and is about 7.46 mm. long and 1.75 mm. wide. The general shape of the shell changes during growth. The form ratios of the first to the ninth volutions of the illustrated specimen are 1.0, 2.3, 3.7, 3.4, 3.5, 2.9, 3.0, 3.3, and 4.3, respectively. The spirotheca is very thin and measures about 23, 28, 28, 47, and 61 microns in the fifth to ninth volutions, respectively.

These specimens resemble in many ways some that were described and illustrated by Dunbar, Skinner, and King (1936) as microspheric individuals of species of *Parafusulina* and some later described by Dunbar and Skinner (1937) as microspheric individuals of *Polydiexodina*. The collection from which we obtained them consists of pebbles from a conglomerate, and several kinds of fusulinids are present in it. If some of them are microspheric individuals, it would seem to be almost impossible to determine which, if any, of the others are megalospheric representatives of the same species.

PARAFUSULINA? sp. D
Plate 6, figures 3–9

The form here designated *Parafusulina?* sp. D is from Collection 35164, composed of pebbles of limestone from the conglomerate at the base of the Triassic? red beds along the Santa Barbara-Mucuchachi road in northwestern Venezuela. Many of the pebbles contain numerous specimens of this fusulinid. In others there are abundant

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EXPLANATION OF PLATE 7

All illustrations on this plate are unretouched photographs, ×10.

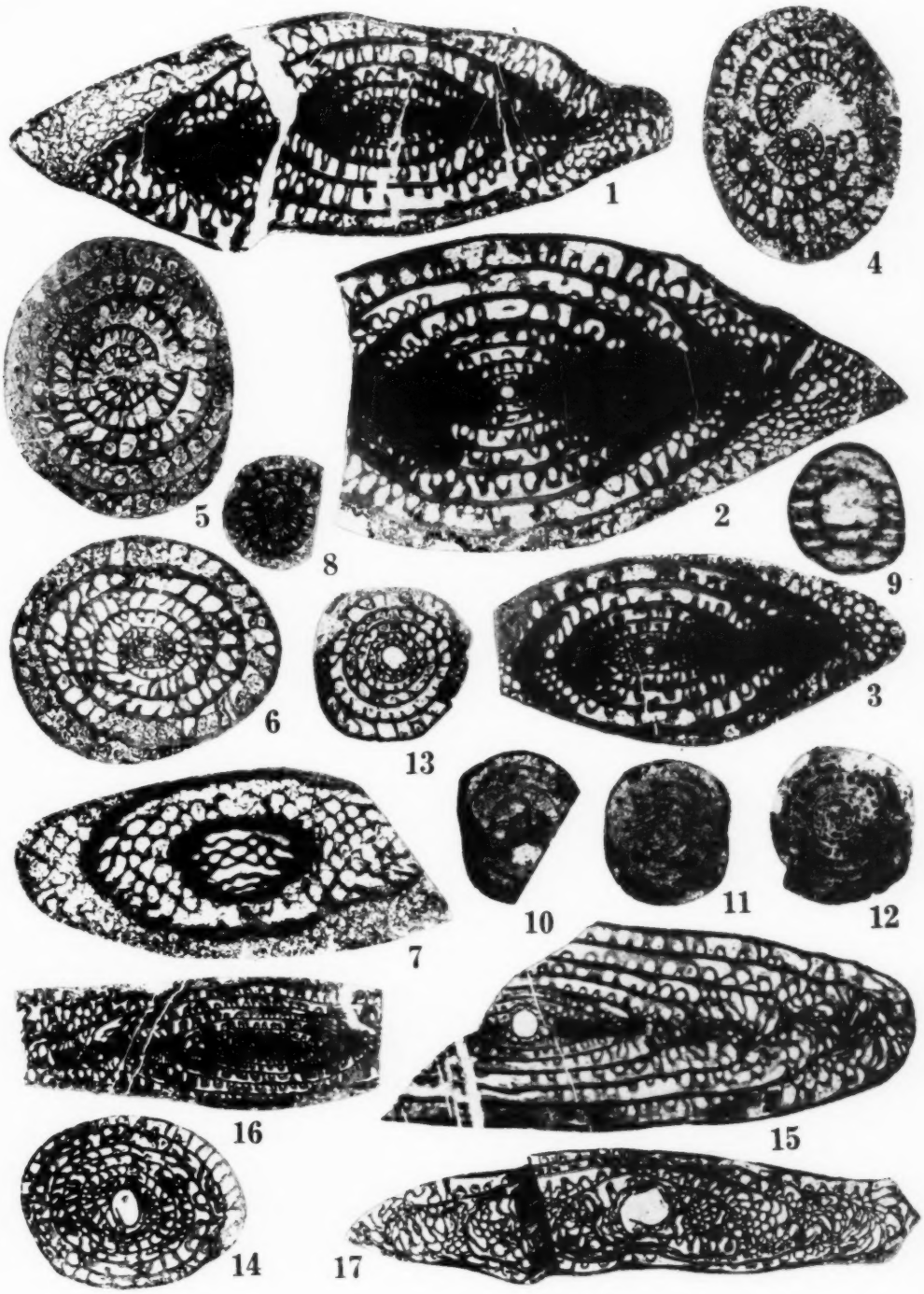
FIGS. *1–7—Schwagerina? hedbergi* Thompson and Miller, n. sp. Axial (fig. *1*), oblique axial (fig. *3*), sagittal (figs. *4–6*), and tangential (fig. *7*) sections of paratypes; and axial section of holotype (fig. *2*). Collection 5006, Colombia. (p. 13)

8–12—Staffella sp. Parallel (fig. *8*), tangential (fig. *9*), axial (figs. *10, 11*), and sagittal (fig. *12*) sections. Collection 19150, Venezuela. (p. 9)

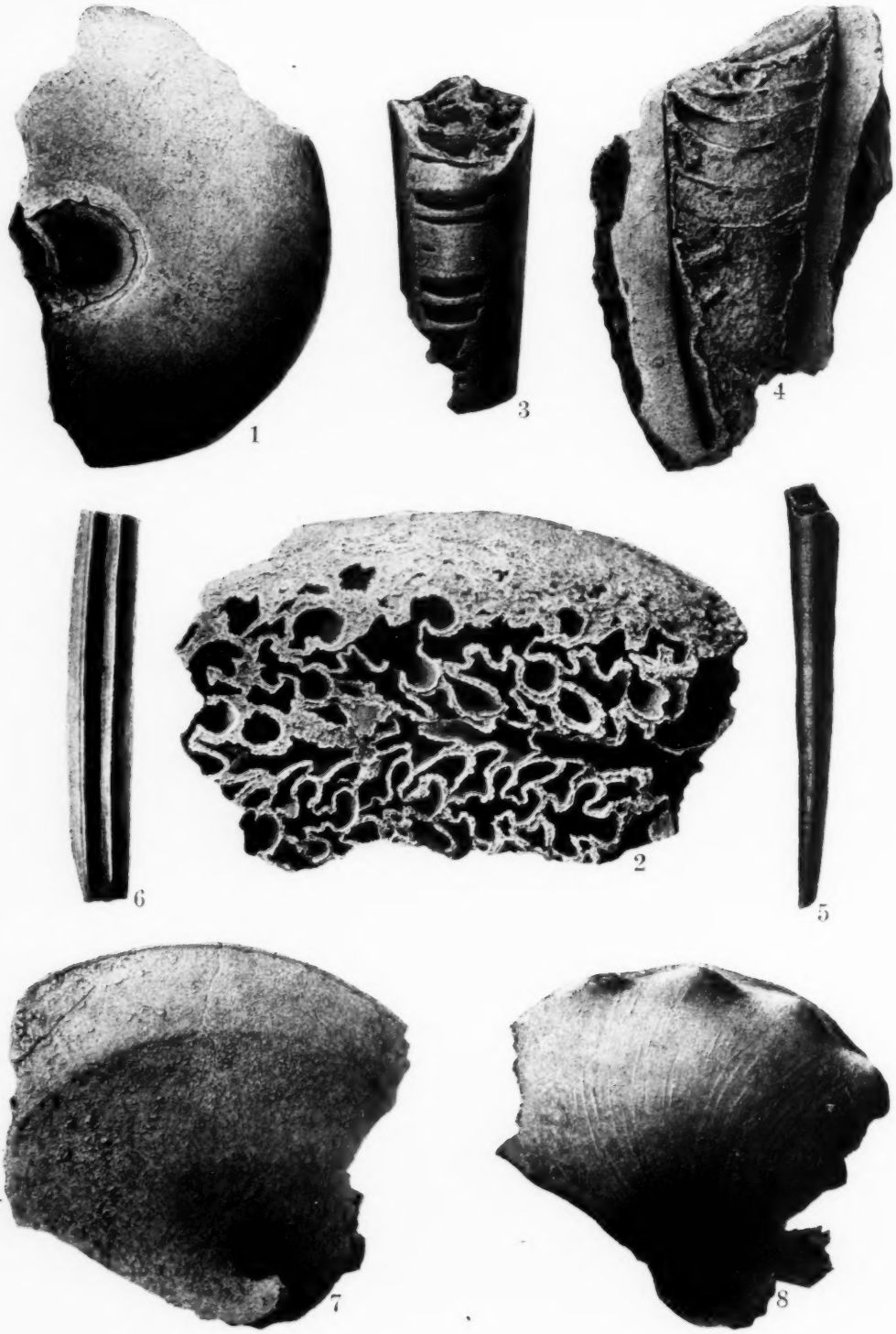
13, 15—Parafusulina sp. B. Sagittal (fig. *13*) and axial (fig. *15*) sections. Collection 19150, Venezuela. (p. 22)

14, 17—Parafusulina sp. A. Sagittal (fig. *14*) and axial (fig. *17*) sections. Collection 19150, Venezuela. (p. 22)

16—Parafusulina? sp. C. Centered axial section. Collection 19150, Venezuela. (p. 22)



Thompson and Miller, Permian Fossils from Maracaibo Region



Thompson and Miller, Permian Fossils from Maracaibo Region

brachiopods but no fusulinids. All of the fusulinid specimens seem to be conspecific and evidently represent an undescribed species. Although we have many sections of this form and it represents a new species, we are not proposing a name for it as we are reluctant to base a species on specimens from pebbles of a conglomerate. Nevertheless, we are illustrating seven specimens and are including statistical data obtained from some of our better oriented sections.

We are not certain as to which genus this form should be referred. The shell is small, long, and slender. Cuneculi are distinctly developed throughout at least most of the shell, the spirotheca is thin, axial fillings are thick, the proloculus is large for the size of the shell and is highly ellipsoidal in shape, and the shell expands uniformly and somewhat gradually. With the exception of size, all of these features are similarly developed in most *Parafusulina*. Several tangential sections and some axial sections show expanded and combined cuneculi that result in structures like the multiple tunnels of typical *Polydiexodina*. The shell of this form is much smaller than that of typical forms of *Polydiexodina*. However, it should be emphasized that size is not a generic character. Tentatively, we are referring this form with question to *Parafusulina*, but it may belong in *Polydiexodina*.

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EXPLANATION OF PLATE 8

Retouched photographs of specimens collected by J. Wyatt Durham (figs. *1*, *2*, *5*, *8*) and O. L. Haught (figs. *3*, *4*, *6*, *7*) from the Middle Permian (Leonard equivalent) on the west slope of the Sierra de Perijá in the Departamento de Magdalena, northern Colombia.

FIGS. *1*, *2*—*Perrinites hilli* (Smith)?. From hill on north side of Quebrada Manaure about 4 (fig. *1*) and 4.5 (fig. *2*) km. east of village of Manaure, ×1 and ×2, respectively. Both came from what Durham "believed to be approximately the same bed." (p. 7)

3–5—*Mooreoceras* spp. From the same locality as fig. *1*, from float limestone in Río Molino about 6 km. upstream from village of Molino, and from same locality as fig. *2*, respectively; ×1½ (fig. *3*) and ×1 (figs. *4*, *5*). The affinities of fig. *5* are uncertain. (p. 7)

6, *7*—*Medlicottia* cf. *M. whitneyi* Böse. From same locality as figs. *1* and *3*, ×1. (p. 7)

8—*Domatoceras* sp. From same locality as figs. *2* and *5*, ×1. (p. 8)

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 25–44, PLS. 9–11, 1 TEXT FIG., JANUARY, 1949

THE TRILOBITE FAUNA OF THE *ELVINIA* ZONE IN THE BASAL WILBERNS LIMESTONE OF TEXAS

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ABSTRACT—Stratigraphic details concerning the Welge sandstone and the lower Morgan Creek limestone members of the Upper Cambrian Wilberns formation of the Llano Uplift in Central Texas are given. The trilobite fauna of these beds represents the *Elvinia* zone and is subdivided into three faunules. Of the sixteen species described three belong to new genera. Four new species are described and the other forms are reviewed in some detail. The paper does not aim at a complete listing of trilobites known from the *Elvinia* zone.

INTRODUCTION

This paper presents the results of a paleontological study of the basal 50 feet of the Wilberns limestone and its contact with the underlying Cap Mountain limestone exposed in the Llano Uplift of Texas. Field work was done between March and November of 1942. Collections were made in measured sections of the base of the Wilberns limestone at 11 localities selected at intervals to complete a circle around the area, the total number of stations being 130. The numerical system used is interpreted as follows: "42" represents the year in which the specimens were collected; "2w", the locality; ".1" the station at the locality, e.g. 42-2w.1. The "42" may be dropped for brevity. Type numbers such as CW-1 refer to the writer's personal collection.

Foremost acknowledgment should be given the help of Dr. William Charles Bell under whose supervision the work was presented as partial fulfillment of requirements for a Master of Arts degree at the University of Texas. His attention to details of preparation of material and photographic technique as well as his painstaking literary criticism was of the greatest benefit. Dr. Christina Lochman Balk, Dr. E. A. Frederickson, Dr. Virgil Barnes, and Mr. V. E. Kurtz furnished the writer with helpful stratigraphic and paleontologic information. Great appreciation is extended to Dr. H. Gordon Damon, Mrs. W. H. Stroud, Judge F. L. Hawkins, and Mr. J. Burney Wilson for their interest and aid in solving the problem of automobile transportation.

LOCALITIES COLLECTED

Figures indicate measured feet above base of Wilberns limestone unless otherwise designated.

42-2w, LION MOUNTAIN—Section at base of north end of hill about 10 miles northwest of Burnet, west-central Burnet County.
- .9—59 feet, *Eoörthis-Billingsella* bed.
- .8—46 feet, white limestone, *Elvinia roemeri*.
- .7—35 feet, white limestone, *Elvinia roemeri*.
- .6—29 feet, red-brown glauconitic limestone.
- .5—25 feet, red limestone, *Plataspella anatina*.
- .4—21 feet, red limestone, *Plataspella anatina*, *Elvinia roemeri*.
- .3—17 feet, red limestone, *Plataspella anatina*.
- .2—16 feet, red limestone, *Plataspella anatina*, *Elvinia roemeri*.
- .1—11 feet, red oolitic limestone, *Plataspella anatina*, *Kindbladia wichitaensis*.

42-3w, WHITE CREEK—5 miles south of Llano-Round Mountain road, 7½ miles west of the Round Mountain community. Section is in a side draw 1½ miles upstream from the Crownover Ranch hunting cabins on White Creek, northwest Blanco County.
- .12—58 feet, *Conaspis* zone fauna.
- .9 —55 feet, *Eoörthis-Billingsella* bed.
- .8 —49 feet, gray-white silty limestone, *Elvinia roemeri*, *Dellea wilbernsensis*, *Camaraspis convexa*, *Dokimocephalus intermedius*, *Pterocephalia sanctisabae*.
- .7 —47 feet, gray silty limestone, cystoid stems.
- .6 —44 feet, hard, dark gray silty limestone.
- .5 —39 feet, hard, white unglauconitic limestone, *Dellea wilbernsensis*.
- .4 —35 feet, soft unglauconitic limestone, *Dellea wilbernsensis*, *Elvinia roemeri*, *Camaraspis convexa*, *Dokimocephalus intermedius*, *Burnetia urania*.
- .3 —27 feet, green glauconitic limestone, *Elvinia roemeri*, *Pterocephalia sanctisabae*.
- .2 —20 feet, white limestone (not in place) *Iddingsia nevadaensis*, *Elvinia roemeri*.

.1 —9 feet, red limestone, *Camaraspis convexa*.
.11—4.5 feet above base of Welge sandstone, *Camaraspis convexa*.
.10—3 feet above base of Welge sandstone, red-brown calcareous sandstone, *Elvinia roemeri, Camaraspis convexa*.

42-4w, PACKSADDLE MOUNTAIN—Near top of knob on north limb of hill about two miles from the Llano-Round Mountain road in southern Llano County.
.5 —14 feet, red limestone.
.4 —3 feet, soft red, oolitic limestone.
.3 —7.5 feet above base of Welge sandstone; hard, white sandstone.
.2 —5.5 feet above base of Welge sandstone, bright orange sandstone.
.1 —2.5 feet above base of Welge sandstone, white sandstone with orange specks, *Kindbladia wichitaensis?, Iddingsia nevadaensis?*

42-6w, BACKBONE RIDGE—Atop ridge just north

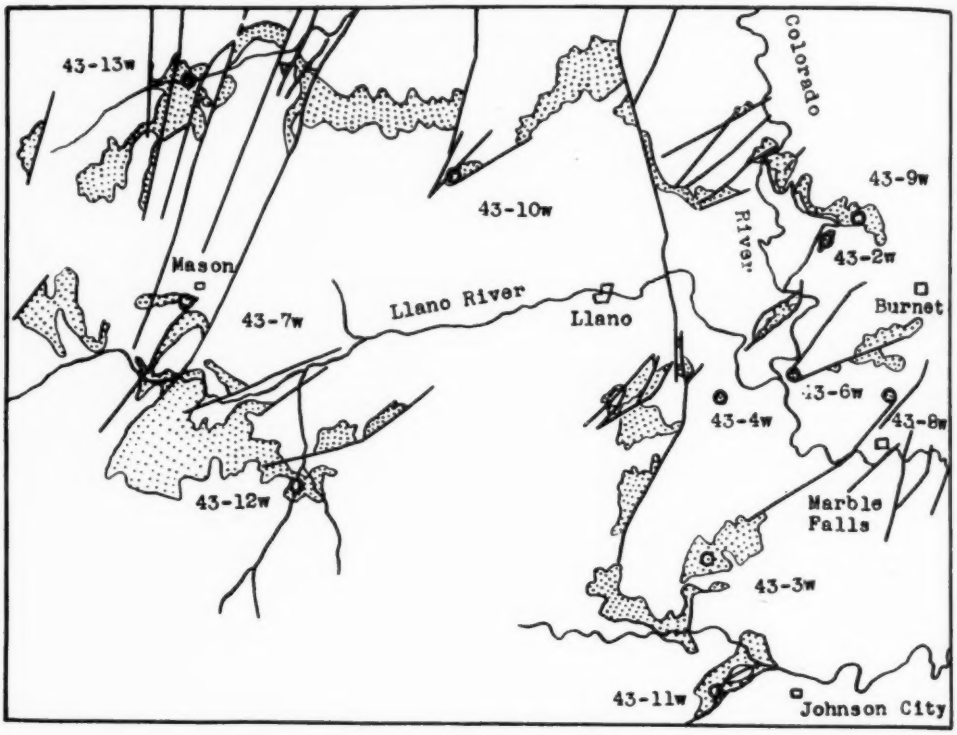


FIG. *1*—Localities collected and Wilberns limestone outcrop in Llano Uplift, Texas.

.13—66 feet, white limestone, *Conaspis* zone fauna, *Eoörthis-Billingsella*.
.12—65.5 feet, *Eoörthis-Billingsella* bed.
.11—64 feet, soft white limestone, *Irvingella burnetensis, Ptychopleurites amploöculata*.
.10—56 feet, white pure limestone, *Elvinia roemeri, Camaraspis convexa, Dokimocephalus intermedius*.
.9 —54 feet, white shelly limestone, *Elvinia roemeri, Berkeia glabellamersa, Dellea wilbernsensis, Camaraspis convexa, Dokimocephalus intermedius*.
.8 —46 feet, red silty limestone, *Irvingella media*.
.7 —39 feet, red gray limestone, *Elvinia roemeri*.
.6 —26 feet, red limestone, *Kindbladia wichitaensis*.

of railroad crossing of Kingsland-Marble Falls road about two miles east of Kingsland, western Burnet County.
.6—52 feet, gray shelly limestone, *Conaspis* zone fauna.
.5—48 feet, *Eoörthis-Billingsella* bed.
.4—44 feet, white limestone, *Camaraspis convexa, Elvinia roemeri*.
.3—36 feet, gray silty limestone.
.2—34 feet, white limestone.
.1—3.5 feet above base of Welge sandstone, white-orange speckled sandstone, *Elvinia roemeri*, unidentified trilobites.

42-7w, WHITE RANCH ROAD—3 miles south of Mason on White Ranch road. Section lies along a slope 1750 feet west of road, central Mason County.
.13—53 feet, *Eoörthis-Billingsella* bed.

.12—50 feet, pure gray limestone, *Ptychopleurites amploöculata, Irvingella burnetensis.*
.11—46 feet, white limestone, *Elvinia roemeri, Dokimocephalus intermedius,* small *Billingsella.*
.10—45 feet, white limestone, *Elvinia roemeri.*
.9 —43 feet, pink-gray limestone.
.8 —41 feet, white glauconitic limestone, *Dellea wilbernsensis, Elvinia roemeri, Berkeia glabellamersa, Camaraspis convexa.*
.7 —39 feet, gray, glauconitic limestone with clay nodules, *Dellea* sp., *Elvinia roemeri, Berkeia glabellamersa, Camaraspis convexa, Burnetia urania.*
.6 —37 feet, gray, glauconitic limestone with clay nodules, *Kindbladia wichitaensis, Dellea* sp.
.5 —36 feet, gray, glauconitic limestone with clay nodules.
.4 —33.5 feet, gray, glauconitic limestone with clay nodules, *Kindbladia wichitaensis, Irvingella media, Elvinia roemeri, Dellea wilbernsensis.*
.3 —24.5 feet, gray, glauconitic limestone.
.2 —13 feet, red, non-glauconitic limestone, *Cheilocephalus* sp., *Plataspella anatina, Dellea wilbernsensis, Kindbladia wichitaensis, Elvinia roemeri.*
.1 —11 feet, red limestone just above white conglomerate.

42-8w, MARBLE FALLS-BURNET HIGHWAY—Four miles north of Marble Falls on Burnet highway. Measured from a small creek bed west of the road up a low hill, southern Burnet County.
.6—49 feet, *Eoörthis-Billingsella* bed.
.5—48 feet, white, shelly, glauconitic limestone, *Irvingella burnetensis, Ptychopleurites amploöculata, Sulcocephalus* sp.
.4—41 feet, gray, glauconitic limestone, *Berkeia glabellamersa, Camaraspis convexa, Dokimocephalus intermedius.*
.3—39 feet, white limestone, *Dellea wilbernsensis, Elvinia roemeri, Pterocephalia sanctisabae, Dokimocephalus intermedius.*
.2—28 feet, gray, shelly limestone, *Elvinia roemeri, Kindbladia wichitaensis, Iddingsia nevadaensis.*
.1—17.5 feet, gray non-glauconitic limestone.

42-9w, BALDY MOUNTAIN—Halfway up west side of Baldy Mountain, located on Lake Buchanan estuary formed by junction of North and South Morgan Creeks. Section is located across the stream from Barnett fishing camp, one mile south of Morgan Creek road at a point 9½ miles north of its junction with the Llano-Burnet highway, northeastern Burnet County.
.16—51 feet, *Eoörthis-Billingsella* bed.
.15—50 feet, yellow-white soft limestone, *Dellea wilbernsensis, Irvingella burnetensis, Irvingella media.*
.14—45 feet, white limestone with yellow spots of siltstone, *Ptychopleurites amploöculata, Irvingella* sp., *Elvinia roemeri.*
.13—41 feet, gray-white limestone with some glauconite, *Elvinia roemeri, Camaraspis convexa, Irvingella* sp.
.12—38 feet, gray-white limestone, *Burnetia urania, Camaraspis convexa, Berkeia glabellamersa, Dellea wilbernsensis, Elvinia roemeri.*
.11—33 feet, white limestone, *Kindbladia wichitaensis, Pterocephalia sanctisabae, Plataspella anatina.*
.10—32.5 feet, white limestone with siltstone nodules, *Iddingsia nevadaensis, Kindbladia wichitaensis, Deadwoodia duris.*
.9 —31.5 feet, white limestone, *Kindbladia wichitaensis, Irvingella* sp., *Deadwoodia duris, Elvinia roemeri, Xenocheilos minutum.*
.8 —27 feet, white limestone, *Kindbladia wichitaensis, Xenocheilos minutum.*
.7 —24 feet, soft white limestone, *Elvinia roemeri, Kindbladia wichitaensis, Plataspella anatina.*
.6 —20 feet, white oolitic limestone, *Elvinia roemeri, Kindbladia wichitaensis, Plataspella anatina.*
.5 —13.5 feet, red oolitic limestone, *Elvinia roemeri, Kindbladia wichitaensis, Plataspella anatina.*
.4 —11.5 feet, gray-brown oolitic limestone, *Elvinia roemeri, Kindbladia wichitaensis, Plataspella anatina.*
.3 —10.5 feet, red-brown soft oolitic limestone, *Kindbladia wichitaensis.*
.2 —2 feet, gray-green glauconitic sandstone.
.1 —1 foot above base of Welge sandstone, white sandstone, *Elvinia roemeri.*

42-10w, SMOOTHINGIRON MOUNTAIN—17 miles northwest of Llano on the Valley Springs road (5 miles past Valley Springs) in the gap between Smoothingiron and Lone Oak Mountains. Section extends along east side of Lone Oak Mountain, north of road and in a pasture at base of hill, northwestern Llano County.
.10—54 feet, white limestone, *Conaspis* zone fauna.
.9 —52 feet, *Eoörthis-Billingsella* bed.
.8 —49 feet, white, shelly limestone, *Ptychopleurites amploöculata, Irvingella burnetensis.*
.7 —45 feet, red limestone, *Kindbladia wichitaensis, Irvingella* sp., *Deadwoodia duris, Elvinia roemeri.*
.6 —43 feet, gray, glauconitic limestone, *Elvinia roemeri, Kindbladia wichitaensis.*
.5 —34 feet, gray, silty limestone, *Camaraspis convexa.*
.4 —26 feet, red and gray limestone.
.3 —22 feet above 10w.2 the top of which is taken as base the Wilberns limestone, soft red limestone.
.2 —31.5 feet above base of Welge sandstone, white and orange sandstone, 4.2 feet thick. This thickness is in part caused by fault repetition.
.1 —15 feet above base of Welge sandstone, orange sandstone.

42-11w, HYE—Section is located in a bluff on north side of Pedernales River, 1½ miles due north of Hye on Wierhausen Ranch. Hye is on

the Johnson City-Fredericksburg highway, western Blanco County.

.12—55 feet, *Conaspis* zone fauna.
.11—54 feet, *Eoörthis-Billingsella* bed.
.10—53 feet, *Eoörthis-Billingsella* bed
.9 —50 feet, gray-white limestone, *Camaraspis convexa.*
.8 —43 feet, white crystalline limestone, *Iddingsia nevadaensis, Camaraspis convexa, Elvinia roemeri, Dellea wilbernsensis.*
.7 —40.5 feet, white crystalline limestone, *Dellea* sp., *Dellea wilbernsensis, Elvinia roemeri.*
.6 —38 feet, gray silty limestone, *Elvinia roemeri.*
.5 —36 feet, pink and dull gray shelly limestone.
.4 —14 feet, red shelly limestone.
.3 —10 feet, red limestone.
.2 —6 feet, red sandy limestone.
.13—4 feet, red shelly limestone, *Plataspella anatina, Elvinia roemeri.*
.1 —base of Wilberns limestone, red sandy, soft limestone.

42-12w, THREADGILL CREEK—Section lies downstream and around a bend from the county road crossing of Threadgill Creek at Lang's Mill. Lang's Mill is 10 miles north of Fredericksburg on the Mason highway, 9.1 miles west of Hilltop Service Station on Doss road. At this point at foot of hill is a road junction on north road of which 3 miles further is Lang's Mill, southeastern Mason County.

.6 —48 feet, *Eoörthis-Billingsella* bed.
.5 —39 feet, white-yellow shelly limestone, *Kindbladia wichitaensis, Dellea wilbernsensis, Elvinia roemeri, Camaraspis convexa, Pterocephalia sanctisabae, Dokimocephalus intermedius, Irvingella* sp.
.4 —38 feet, gray shelly limestone, *Burnetia urania, Camaraspis convexa.*
.3 —36 feet, gray silty limestone, *Dokimocephalus intermedius, Elvinia roemeri.*
.2 —26 feet, gray, crystalline limestone, *Kindbladia wichitaensis, Plataspella anatina, Irvingella burnetensis, Irvingella media, Xenocheilos minutum, Deadwoodia duris, Elvinia roemeri.*
.1 —25 feet, white crystalline limestone, *Kindbladia wichitaensis, Plataspella anatina.*

Collections from the following stations were furnished the writer by Dr. Virgil Barnes who measured this section earlier:

.14—45 feet, gray limestone, *Sulcocephalus benesulcatus, Ptychopleurites amploöculata, Irvingella media, Irvingella burnetensis.*
.13—43 feet, gray limestone, *Ptychopleurites amploöculata.*
.12—42.5 feet, gray limestone, *Dokimocephalus intermedius, Burnetia urania, Dellea wilbernsensis, Pterocephalia sanctisabae.*
.11—40 feet, gray limestone, *Pterocephalia sanctisabae, Dellea wilbernsensis.*
.10—35 feet, gray limestone, *Dokimocephalus intermedius, Deadwoodia duris.*
.9 —22.5 feet, red limestone.
.8 —20 feet, red limestone, *Kindbladia wichitaensis.*
.7 —5 feet, red limestone, *Platasella anatina.*

42-13w, CAMP SAN SABA—At ford of San Saba River near Camp San Saba monument. Welge sandstone is exposed ¼ mile downstream from ford where basal Wilberns limestone crops out. Via the road on south side of river, ford is 1¼ miles downstream from Mason-Brady highway crossing of river 19 miles north of Mason, southern McCulloch County.

.12—39 feet, *Eoörthis-Billingsella* bed.
.11—39 feet, *Elvinia roemeri, Dokimocephalus intermedius.*
.10—38 feet, small eoörthoid brachiopods.
.9 —37 feet, red-gray limestone, *Dokimocephalus intermedius. Camaraspis convexa, Elvinia roemeri, Dellea wilbernsensis.*
.8 —34 feet, gray limestone, *Elvinia roemeri, Camaraspis convexa.*
.7 —33.5 feet, white, soft, crystalline limestone, *Kindbladia wichitaensis ?, Pterocephalia sanctisabae, Camaraspis convexa, Elvinia roemeri.*
.6 —31.5 feet, white, soft crystalline limestone, *Burnetia urania, Acrocephalites lataegenae, Dokimocephalus intermedius, Pterocephalia sanctisabae, Camaraspis convexa, Elvinia roemei, Dellea wilbernsensis.*
.5 —29 feet, hard, gray limestone, *Elvinia roemeri.*
.4 —22.5 feet, hard, gray limestone, *Elvinia roemeri.*
.3 —17.5 feet, hard gray limestone, *Kindbladia wichitaensis, Elvinia roemeri.*
.2 —14 feet, hard, red-gray limestone, *Kindbladia wichitaensis.*
.1 —1 foot below base of Morgan Creek member, Welge sandstone, limey, orange colored, *Plataspella anatina, Elvinia roemeri.*

STRATIGRAPHY

In 1912 Sidney Paige described the Upper Cambrian beds of the Llano Uplift, showing that they comprised the following formations in stratigraphic order: Hickory sandstone, Cap Mountain limestone, Wilberns limestone, and the lowermost portion of the Ellenburger group (1912), pp. 6, 7). A glauconitic sandstone at the top of the Cap Mountain limestone was distinguished by Bridge (1937a, p. 234) and was given the name Lion Mountain. Lochman (1938) has demonstrated that the Cap Mountain limestones contain *Cedaria* and *Crepicephalus* zone faunas, and that the fossiliferous limestone lenses of the Lion Mountain greensand carry an *Aphelaspis* fauna. Work by Bridge (1937b) and by Bridge, Cloud, and Barnes (1947, pp. 113–115) has contributed greatly toward a better understanding

of both stratigraphy and faunal sequence in this region. These authors include the Hickory, Cap Mountain, and Lion Mountain members in the Riley formation which is overlain by the Wilberns formation whose lower boundary is still the top of the Lion Mountain sandstone.

This paper is concerned with the fauna of the two lower members of the Wilberns formation, i.e., the Welge sandstone and Morgan Creek limestone, and aims at a description of the most frequently encountered trilobites which comprise the well known *Elvinia* fauna of the mid-continent and western United States. The Welge sandstone, orange to reddish brown and almost non-glauconitic is easily differentiated from the underlying Lion Mountain glauconitic sandstone. Generally the sandstone is composed of pure quartz grains cemented with limonite. According to Barnes (1947, p. 114) who named the member from Gillespie County, the Welge sandstone is thickest to the north and west parts of the uplift. This is confirmed by the writer's measurements which show it to be absent in the extreme northeast along Lion Mountain, only 3 feet thick a mile north on Baldy Mountain, about 10 feet in the central and southern portions of the uplift, and between 20 and 30 feet both in the north and southwestern edges of the Llano area. Three types of beds are noticeable in the Welge outcrops: a thin, hard, gray-green, glauconitic limey sandstone near its top; an orange white, very calcareous sandstone of varying thickness and stratigraphic position and often bearing an *Elvinia* fauna; and a bright orange, soft weathering friable sandstone, usually of considerable thickness. The latter bed was noted only in the western portion of the uplift, where the thickening of the section is apparently caused by its presence. All trilobites collected from the Welge occurred in the orange-white calcareous sandstone on the eastern side of the uplift. The fauna comprises *Elvinia roemeri* (Shumard), *Plattaspella anatina* (Resser), *Camaraspis convexa* (Whitfield), and *Kindbladia wichitaensis* (Resser) as well as several undescribed fragmentary cranidia. The fauna is the same as that in the lowest beds of the Morgan Creek member and constitutes the lowest subdivision of the *Elvinia* fauna.

The Morgan Creek limestone member of the Wilberns formation was named by Bridge (Bridge, Cloud, and Barnes, 1947, p. 114) from exposures in northeastern Burnet County. These authors note that its lower boundary is transitional from the Welge sandstone which grades into the reddish, sandy, oolitic limestones that constitute the basal beds of the Morgan Creek. The writer observed that this softer weathering brick red limestone continues through a rather constant 25 feet although the sandy layers are confined to the lower few feet. As the red color fades, the beds become more fossiliferous and glauconitic, and either pinkish gray or pure white in color. The limestone may be very crystalline, contain small quantities of silt, or be composed solely of trilobite remains replaced by calcite. Bridge, Cloud, and Barnes include an average of 110 feet of thin-bedded limestone in the Morgan Creek and draw its upper boundary somewhat arbitrarily at the base of the Point Peak shale member. The Morgan Creek member contains the *Elvinia* fauna followed by conaspid trilobites whose range includes the *Eoörthis* and *Billingsella* brachiopod subzones. The writer is concerned only with the trilobites of the *Elvinia* zone and measured sections only as far up as the first occurrence of conaspid trilobites above the first thick brachiopod bed. The interval between the base of the Morgan Creek reddish sandy limestone and the base of the lowest brachiopod coquina ranged from 39 feet (Camp San Saba) to 66 feet (Packsaddle Mountain), but in most localities it was a little over 50 feet.

The fauna collected from the Welge and lower Morgan Creek members of the Wilberns limestone is typically that of the *Elvinia* zone (Ironton fauna of the Franconia formation of Wisconsin). It is best represented by the following species:

Acrocephalites lataegenae Wilson, n. sp.
Berkeia glabellamersa Wilson, n. sp.
Burnetia urania (Walcott)
Camaraspis convexa (Whitfield)
Cheilocephalus sp.
Dellea wilbernsensis Wilson, n. gen., n. sp.
Dokimocephalus intermedius (Resser)
Elvinia roemeri (Shumard)
Iddingsia nevadaensis Resser

Irvingella burnetensis Resser
Irvingella media Resser
Kindbladia wichitaensis (Resser)
Plataspella anatina (Resser)
Pterocephalia sanctisabae Roemer
Ptychopleurites amploöculata Frederickson
Xenocheilos minutum Wilson, n. gen., n. sp.

The more common trilobites in the *Elvinia* zone may be divided into three groups according to stratigraphic position:

Group 1. The *Plataspella* subzone (Welge sandstone and basal 30 feet of the Morgan Creek—red oolitic sandy portion—fossils scarce.)
Kindbladia wichitaensis (Resser)
Plataspella anatina (Resser)
Iddingsia nevadaenis Resser

Group 2. The *Dellea-Burnetia* subzone (30 to 50 feet above the base of the Morgan Creek member—fossils abundant.)
Deadwoodia duris (Walcott)
Dokimocephalus intermedius (Resser)
Burnetia urania (Walcott)
Pterocephalia sanctisabae Roemer
Dellea wilbernsensis Wilson, n. sp.

Group 3. The *Irvingella* subzone (1 to 5 feet below the base of the *Eoörthis-Billingsella* bed—top of the *Elvinia* zone, 1 or 2 feet of very fossiliferous limestone.
Irvingella burnetensis Resser
Irvingella media Resser
Ptychopleurites amploöculata Frederickson
Sulcocephalus benesulcatus Wilson

Elvinia roemeri (Shumard) and *Camaraspis convexa* (Whitfield) extend from the base of the Welge sandstone through the *Irvingella* subzone at the very top of the *Elvinia* zone. These two species are not only the longest ranging, but also are the most abundant in the zone. Further collecting may show, as has already proved to be the case for species of *Kindbladia* and *Irvingella*, that some of the genera transgress the "boundaries" of the subzones, but it is believed that the above list represents time of maximum abundance of the species in question within this area. E. A. Frederickson (personal communication, 1947) has indicated that in the Honey Creek limestone of Oklahoma much the same general subdivisions of the *Elvinia* zone exist.

None of the species in the lower Morgan Creek member seems to be geographically restricted, and although neither the *Plataspella* nor *Irvingella* subzone was found at all localities, it is considered probable that more extended search will reveal the species in their proper horizons at all localities. No evidence of facies control of any of the trilobites was observed.

The top of the *Elvinia* zone is marked everywhere over the uplift, as in all other Mid-Continent Upper Cambrian exposures, by the base of beds containing eoörthoid brachiopods. In most Texas sections the lowest occurrence of abundant eoörthoid brachiopods is a prominent bed only about three feet thick or less which contains species of *Eoörthis* with some *Billingsella*. For more detailed observation on the brachiopod ranges see Bridge, Cloud, and Barnes (1947, p. 115). The brachiopod coquinas contain as well a *Conaspis* zone trilobite fauna including *Orygmaspis*, *Stigmacephalus*, and *Taenicephalus*. No *Elvinia* zone forms were found at this horizon, and it is probable that no mixing of trilobite faunas occurs. However, both brachiopod genera are also associated with the older trilobite fauna and at several localities within the top beds of the *Elvinia* zone small forms of *Billingsella?* occur one to five feet below the main brachiopod beds.

The *Elvinia* fauna has long been known as the Ironton fauna because of its presence in the Ironton member of the Franconia formation of Wisconsin in the standard Croixan section. The following is a list of formations in the United States known to be Ironton equivalents:

The Appalachians

Potsdam sandstone (dolomitic beds near top)—Lake Champlain region.

Ore Hill limestone—Central Pennsylvania.

Lower Conococheague limestone—Central Appalachians.

Mid-Continent Area

Welge and lower Morgan Creek members of Wilberns limestone—Llano Uplift, Texas.

Lower Honey Creek limestone—Central Oklahoma.

Lower Davis limestone—Ozark Dome, Missouri.

Rocky Mountains and Western United States

Basal Snowy Range formation—Montana and northern Wyoming.

Horizon in Deadwood formation—Black Hills, South Dakota.

Snowy Range members of Boysen formation—Teton and Gros Ventre Ranges, Wyoming.

Upper Orr formation—House Range, Utah.

Lower Pogonip limestone—White Pine District, Nevada.

Horizon above Secret Canyon shale—Eureka District, Nevada.

Lower St. Charles limestone—Northeast Utah.

Rincon limestone, Peppersauce shale—Arizona.

For further correlation in the western United States see John F. Mason (1938, p. 288, chart). The importance of the genus *Acrocephalites* in correlation with the Upper Cambrian sections of Novaya Zemlya, Scandinavia, Newfoundland, and New Brunswick (*Olenus* zone of the North Atlantic province) is stressed by Howell and Lochman (1939, pp. 115–122). The Texas section bears out well the fact noted by the foregoing authors that the faunal break at the base of the *Elvinia* zone is a considerable one. From the present state of knowledge it appears likely that no genus transgresses the boundary between the lower three trilobite zones of the Upper Cambrian and the Ironton assemblage. That the *Elvinia* fauna is associated with or follows immediately after a period of clastic sedimentation is also pointed out by Howell and Lochman (1939, p. 121). The Texas sections demonstrate this clearly. The barren uppermost greensands of the Lion Mountain member of the Riley formation give way rather suddenly to the more calcareous and oxidized sandstones of the Welge member which grade into the Morgan Creek limestones. The calcareous sandstone of the Welge member initiates the *Elvinia* fauna, but trilobite remains do not become abundant until the pure limestone layers occur some 25 feet above the sandy base of the Morgan Creek member of the Wilberns.

Systematic Descriptions

Genus Acrocephalites Wallerius 1895

Acrocephalites lataegenae Wilson, n. sp.

Plate 10, figure 14

Cranidium very small (4.5 by 3 mm.), wider than long, and highly convex. Glabella sunken, sharply crested, tapered anteriorly to two-thirds its basal width, length about half that of entire cranidium; dorsal furrow deep and wide; three pairs of glabellar furrows present: anterior pair faint, but posterior pairs long, oblique, and unusually wide and deep; occipital furrow straight and as wide and deep as glabellar furrows; occipital ring wide medially but tapers sharply laterally. Border short, convex, sharply defined by distinct marginal furrow, and well tapered laterally; brim twice as wide as border at center and one-third length of glabella, strongly depressed laterally and bears a large swelling immediately anterior to the glabella; fixed cheeks two-thirds as wide as glabella, greatly elevated at lateral edges, depressed posteriorly; palpebral lobes missing; ocular ridges wide, prominent, and arched horizontally across anterior ends of fixed cheeks; posterior limbs straight, moderately wide, very long, greatly depressed, and traversed by furrows that widen noticeably toward their extremities.

Facial suture proceeds slightly outward from anterolateral corner of cranidium to lateral extremity of ocular ridge, course around palpebral lobe unknown, but it trends posterolaterally at an angle of 45° with the longitudinal axis.

Palpebral lobe, free cheek, and pygidium unknown.

Surface granulation coarse.

Remarks.—Acrocephalites lataegenae resembles the genotype, *A. stenometopus* Angelin in that it possesses a noticeable preglabellar swelling, wide fixed cheeks, and

coarse surface granulation. Its small size and deep wide glabellar furrows are outstanding characteristics of *A. lataegenae*. That the presence of true *Acrocephalites* species in the Ironton equivalents of North America affords a correlation with the European *Olenus* zone has been pointed out by Howell and Lochman (1939, pp. 115–117 and 120, 121). The writer has collected this or a very similar species also from the Ore Hill limestone of central Pennsylvania and such forms are present in the Ironton of Wisconsin.

Occurrence.—A single specimen was found in a coquina of *Camaraspis convexa* (Whitfield) in the middle portion of the *Elvinia* zone, Station 13w.6.

Holotype.—CW-35, Sta. 13w.6.

Genus BURNETIA Walcott 1924
BURNETIA URANIA (Walcott)
Plate 9, figures 3, 9, 10

Ptychoparia (?) *urania* WALCOTT, 1890, U. S. Nat. Mus. Proc., p. 274, pl. 21, figs. 10, 11.
Burnetia urania WALCOTT, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 54, pl. 10.
Burnetia urania WALCOTT, 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 77, pl. 17, figs. 1–3.

Supplementary Description.—Cranidium either large or moderate in size, highly convex, about as long as wide. Glabella large and prominent, bulbous, its greatest height being near its slightly tapered anterior end; dorsal furrow deep and wide; two pairs of glabellar furrows present: anterior pair faint, short, and oblique, posterior pair long, deep, and curved strongly backward medially; occipital furrow very wide and deep throughout its course; occipital ring straight and laterally untapered. Border concave or flat, width equal to half length of glabella, the course of its anterior margin and distinct marginal furrow giving it the shape of a wide crescent; brim reduced to a narrow band across preglabellar area, but widens laterally where it slopes up almost vertically to join the fixed cheeks; fixed cheeks extremely convex longitudinally, slope upward transversely from dorsal furrow so that palpebral lobes are only slightly lower than dorsal surface of glabella; palpebral lobes small, elevated and located slightly posterior to transverse median line of cranidium; ocular ridges very faint and oblique; posterior limbs unknown from Texas specimens.

Facial suture probably intramarginal to center, trends outward to anterolateral corner of cranidium from which it curves

EXPLANATION OF PLATE 9

FIGS. *1, 2, 4, 5—Dokimocephalus intermedius* (Resser). *1*, Hypotype; dorsal, ×2, of moderate sized cranidium, CW-13, Sta. 8w.3. *2*, Hypotype; dorsal squeeze of cranidium, ×2, CW-11, Sta. 12w.5. *4*, Hypotype; dorsal view of large cranidium, ×2, CW-16, Sta.8w.3. *5*, Hypotype; pygidium, ×2, CW-15, Sta. 3w.4. (p. 37)

3, 9, 10—Burnetia urania (Walcott). *3*, Hypotype; dorsal view of moderate sized cranidium, ×2, CW-8, Sta. 9w.12. *9, 10*, Hypotype, dorsal and profile views, ×2, of moderate sized cranidium, CW-9, Sta. 13w.6. (p. 32)

6–8, 19—Iddingsia nevadaensis Resser. *6*, Hypotype; dorsal view, ×1, of cranidium, the crest of glabella restored, CW-28, Sta. 8w.2. *7, 8*, Hypotype; dorsal and profile views, ×1, of cranidium, CW-27, Sta. 3w.2. *19*, Hypotype; squeeze of pygidium, ×1, CW-29, Sta. 8w.2. (p. 38)

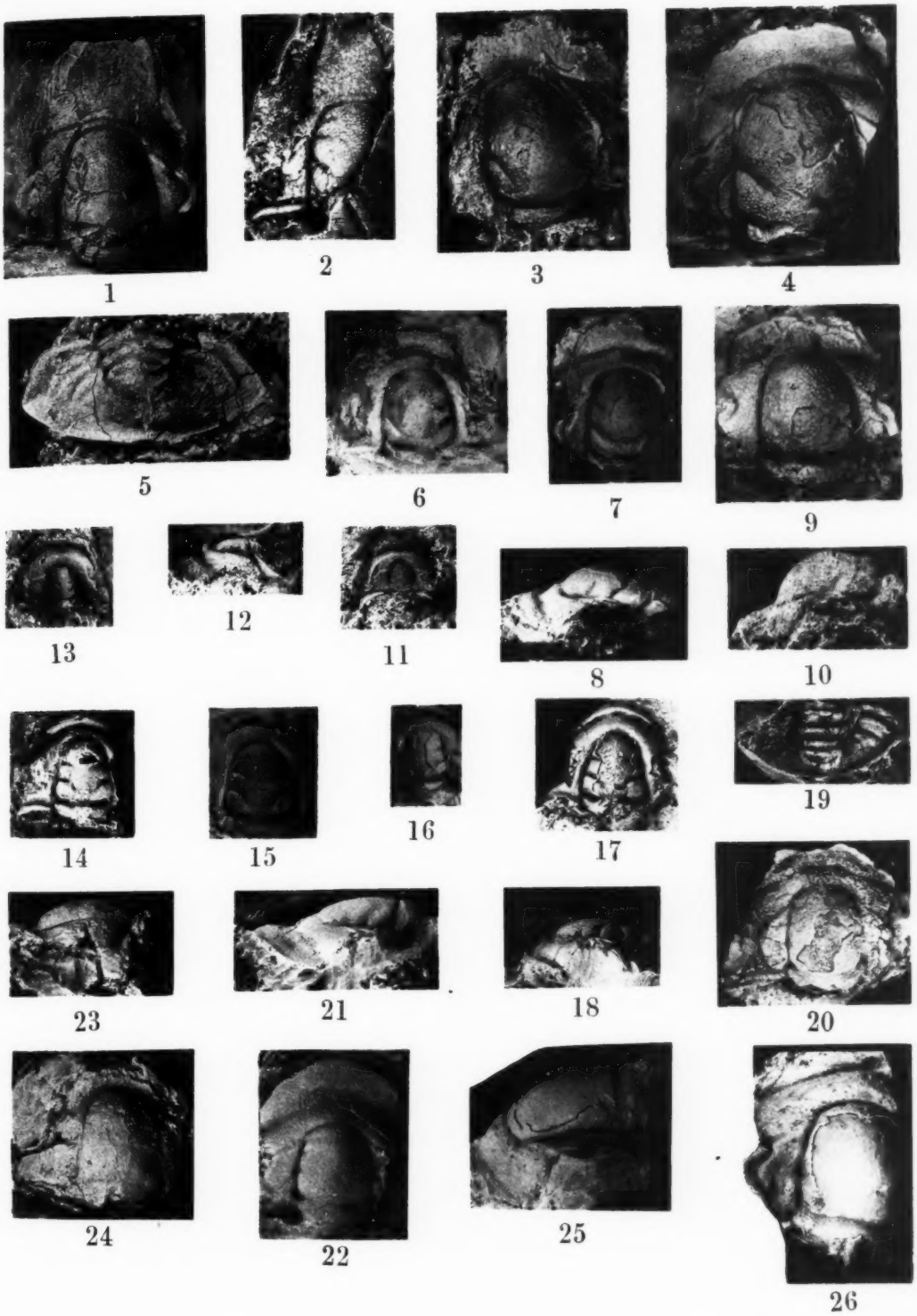
11–13—Xenocheilos minutum Wilson, n. sp. *11, 12*, Holotype; dorsal view, ×3, and profile view, ×4, of cranidium, CW-62, Sta. 12w.2. *13*, Paratype; dorsal view, ×3, of larger fragmentary cranidium, CW-61, Sta. 9w.9. (p. 44)

14–18—Kindbladia wichitaensis (Resser). *14*, Hypotype; dorsal view, ×2, of moderate sized cranidium, CW-18, Sta. 10w.7. *15*, Hypotype; dorsal view, ×2, of largest cranidium, CW-20, Sta. 8w.2. *16*, Hypotype; dorsal view, ×2, of small cranidium, CW-19, Sta. 9w.4. *17, 18*, Hypotype; dorsal and profile views, ×2, of moderate sized cranidium, CW-17, Sta. 12w.2. (p. 40)

20–22—Plataspella anatina (Resser). *20*, Hypotype; dorsal view, ×1, of badly preserved cranidium, CW-25, Sta. 2w.5. *21, 22*, Hypotype; profile and dorsal views, ×1, of incomplete cranidium, CW-24, Sta. 2w.4. (p. 42)

25, 26—Plataspella anatina (Resser)? *25, 26;* profile and dorsal views, ×2, of small fragmentary cranidium possibly belonging to this species, CW-26, Sta. 12w.2. (p. 42)

23, 24—Cheilocephalus sp. *23, 24;* profile and dorsal views, ×2, of poorly preserved cranidium, CW-39, Sta. 7w.2. (p. 34)



Wilson, *Elvinia* Zone Trilobites from Texas

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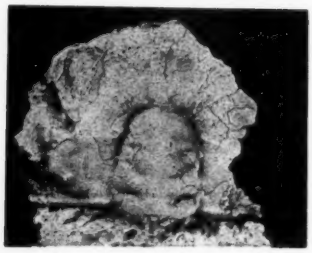

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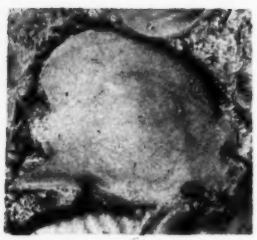

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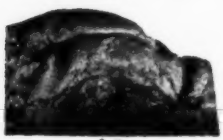

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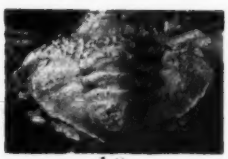

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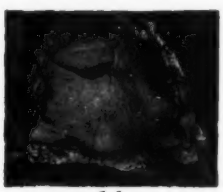

11

Wilson, *Elvinia* Zone Trilobites from Texas

inward to palpebral lobe; further course unknown.

Cranidium strongly pustulose except on border.

Pygidium unknown, although it is possible that the one assigned to *Dokimocephalus intermedius* (Resser) (pl. 9, fig. 5) is really that of *Burnetia urania*.

Occurrence.—Seemingly restricted to the middle portion of the *Elvinia* zone from 30 to 45 feet above the base of the Wilberns limestone; associated with the related form *Dokimocephalus intermedius* (Resser) and with *Dellea wilbernsensis* Wilson, n. sp. at stations 3w.4, 7w.7, 9w.12, 12w.4, 12w.12, 13w.6.

Hypotypes.—CW-8, Sta. 9w.12 and CW-9, Sta. 3w.4.

Genus CAMARASPIS Ulrich and Resser 1924

CAMARASPIS CONVEXA (Whitfield)

Plate 10, figures 6, 8, 11

Arionellus (Agraulos) convexus WHITFIELD, 1878, Wisconsin Geol. Survey, Ann. Rept. for 1877, p. 57.

Arionellus convexus WHITFIELD, 1882, Geology of Wisconsin, vol. 4, p. 190, pl. 1, fig. 17.

Camaraspis convexus (Whitfield), ULRICH and RESSER MS., Ulrich, 1924, Wisconsin Acad. Sci., Arts, and Letters, vol. 21, p. 94.

Supplementary Description.—Cranidium one and a half times as wide as long, strongly convex both transversely and longitudinally, its general appearance smooth, there being no individually convex features on it. Glabella low and flat, barely rising above fixed cheeks, having in some specimens a thin ridge along its longitudinal crest, anteriorly depressed, following in that direction the general downward curvature of the cranidium; dorsal furrow wide and very shallow; glabellar furrows absent in almost all specimens, traces of three oblique pairs visible on a few individuals; occipital furrow straight and shallow; occipital ring widens very gradually to center. Border flat and faint, defined by an almost invisible marginal furrow, its width about half that of brim, its anterior margin describing a wide arc; brim moderately wide, its preglabellar width almost equal to that of its lateral portions, and in longitudinal profile continues the downward slope of the anterior part of glabella; fixed cheeks half width of glabella, longitudinally depressed in both directions, perfectly flat or gently sloping away from glabella in transverse profile; palpebral lobes depressed, small, crescent-shaped, their anterior ends about at the transverse median line of cranidium; ocular ridges faint, their course almost paralleling that of the marginal furrow; posterior limbs short, extended at right angles to longitudinal axis, traversed by a shallow furrow which widens and becomes more distinct laterally.

Facial suture passes slightly inward in proceeding from anterolateral corner of cranidium to anterior end of palpebral lobe, rounds palpebral lobe, indents slightly just behind it and passes posterolaterally along anterior margin of limb.

Free cheeks and pygidium unknown.

EXPLANATION OF PLATE 10

FIGS. *1–3—Pterocephalia sanctisabae* Roemer. *1*, Hypotype; pygidium, ×2, CW-56, Sta. 12w.11. *2*, Hypotype; dorsal view, ×2, of fragmentary cranidium, CW-57, Sta. 13w.7. *3*, Hypotype; squeeze of fragmentary cranidium, ×2, CW-55, Sta. 13w.6. (p. 42)

4—Ptychopleurites amploöculata Frederickson. Hypotype; dorsal views, ×4, of pygidium and cranidium with *Irvingella media*, CW-58a, and CW-58b, Sta. 12w.14. (p. 42)

6, 8, 11—Camaraspis convexa (Whitfield). *6*, Hypotype; profile view, ×2, of cranidium CW-36, with frontal view of cranidium CW-37, with pygidium of *Pterocephalia sanctisabae*, Sta. 13w.6. *8*, Hypotype; dorsal view, ×2, of cranidium CW-37, Sta. 13w.6. *11*, Hypotype; dorsal view, ×2, of moderate-sized cranidium, CW-38, Sta. 13w.6. (p. 33)

7—Irvingella media Resser. Hypotype; squeeze of pygidium, ×3, whose anterior pointing projection at the upper left corner is probably a fragment of another trilobite, CW-3, Sta. 12w.14. (p. 39)

5, 9, 10, 12, 13—Elvinia roemeri (Shumard). *5*, Hypotype; free cheek, ×1, CW-45, Sta. 12w.4. *9*, Hypotype; dorsal view, ×1, of cranidium, CW-47, Sta. 3w.2. *10*, Hypotype; pygidium, ×1, Cw-46, Sta. 13w.6. *12, 13*, Hypotype; profile and dorsal views, ×1, of moderate sized cranidium, CW-44, Sta. 10w.6. (p. 38)

14—Acrocephalites lataegenae Wilson, n. sp. *14*, Holotype; dorsal view, ×8, of cranidium, CW-35, Sta. 13w.6. (p. 31)

Remarks.—The Texas specimens are wholly identical with the genotype in degree of convexity. The larger forms from the Welge sandstone are not quite so convex as the others, probably a circumstance resulting from differences in matrix rather than any structural difference in the fossils.

Occurrence.—Moderately abundant in the Welge sandstone member, no forms collected from the lower 30 feet of the Morgan Creek member, abundant in the middle portion of the *Elvinia* zone 30 to 55 feet above the base of the Morgan Creek member, and present at one locality in the *Irvingella* subzone. At most stations at which it was collected the species occurred in great abundance, often being the major constituent of a trilobite coquina. It is not so common in the *Elvinia* zone of the Wilberns limestone as *Elvinia roemeri*, but it is a good index fossil here as well as in Wisconsin, where the zone is known by its name. Stations 2w.8, 3w.4, 4w.10, 3w.11, 4w.9, 4w.10, 6w.4, 7w.7, 7w.8, 8w.4, 9w.12, 9w.13, 10w.5, 11w.8, 11w.9, 12w.4, 12w.5, 12w.13, 13w.6–13w.9.

Hypotypes.—CW-36 and CW-37 (two cranidia on same piece of rock), and CW-38, Sta. 13w.6.

Genus CHEILOCEPHALUS Berkey 1898
CHEILOCEPHALUS sp. undet.
Plate 9, figures 23, 24

Cranidium of very simple structure, moderately convex, evenly arched in transverse profile. Glabella very large and tapered slightly, its anterior corners rounded, frontal margin straight, transverse profile evenly convex, and in longitudinal profile gently depressed anteriorly; dorsal furrow narrow but distinct; glabellar furrows absent; occipital furrow faint; occipital ring widest at center. Border absent; brim concave and narrow, its width about one-fifth length of glabella; fixed cheeks slightly wider than brim, slope gently to merge with it and slope gradually away from glabella to continue its even arch; posterior limbs long and comparatively wide, evenly depressed away from glabella, and traversed by a wide and shallow furrow.

Facial suture rounds anterolateral corner, proceeds posteriorly a short distance, bends outward at a point anterior to medial axis of glabella and then passes abruptly inward to make a sharp indentation just before proceeding posterolaterally at a 70° angle with the longitudinal axis.

Remarks.—The form collected differs from the genotype, *Cheilocephalus stcroixensis* Berkey, in having a somewhat smaller cranidium with less convexity and long and narrower posterior limbs. The material illustrated is fragmentary and no specific determination is attempted.

Occurrence.—Two specimens of *Cheilocephalus* were found at a single locality (7w.2) in the basal part of the *Elvinia* zone in the Morgan Creek member of the Wilberns limestone. One species, *Cheilocephalus wichitaensis*, was described by Resser from the Honey Creek limestone of Oklahoma. Another species of the genus is present in the Ironton of Wisconsin and a third in the equivalent Ore Hill limestone member in Pennsylvania (Berkey, 1898, p. 289 and Resser, 1942, p. 36). In addition Resser (1942, p. 35) has described *C. texanus* from the Hickory sandstone member of the Riley formation of Texas. After examination of the single poorly preserved specimen upon which this species is based the writer concludes that the trilobite quite likely belongs to the genus *Kingstonia*.

Hypotype.—CW-39, Sta. 7w.2.

Genus DELLEA Wilson, n. gen.

Cranidium very convex and varies in size from 3½ to 9 mm. in length and 6½ to 12½ mm. in width; length between two-thirds and one-half of width. Glabella prominent, stands high above fixed cheeks, anteriorly tapered to two-thirds its basal width, length varies specifically; dorsal furrow moderately deep; glabellar furrows vary in depth but usually are faintly impressed, anterior pair often invisible, posterior pairs often turn abruptly backward; occipital furrow deep and wide, occipital ring narrows and is directed forward laterally. Border widely arcuate and widens gradually to center, in longitudinal profile almost horizontal; marginal furrow deep, brim steeply depressed, continues slope of anterior portion of glabella, fairly wide laterally, at center line varies from twice to equal width of rim; fixed cheeks about one-third width of glabella, always under one-half its width,

moderately convex, palpebral lobes rather long, centrally located, ocular ridge moderately prominent, oblique, posterior limbs very wide, bear a broad and deep furrow which narrows at intersection with dorsal furrow.

Facial suture probably originates lateral to center line of cranidium and after indenting slightly past anterolateral corners of cranidium encircles elongate palpebral lobes and is directed posterolaterally at about a 45° angle with the longitudinal axis.

Remarks.—*Dellea* resembles *Modocia* but differs in having much narrower fixed cheeks and a more steeply depressed and centrally wider brim, and in general a greater degree of convexity. The genus resembles *Dunderburgia* but has a much more tapered glabella and larger palpebral lobes. It is also close to the genotype, *Berkeia typica* Resser, in all its proportions, but is much less deeply furrowed and lacks the convex preglabellar area and fixed cheeks of this species.

The genus is very common in the *Elvinia* zone in Oklahoma, Pennsylvania, Wisconsin, and New York, as well as in Texas.

Genotype: *Dellea wilbernsensis* Wilson, n. sp.

DELLEA WILBERNSENSIS Wilson, n. sp.
Plate 11, figures 1, 2, 4–7, 12

Length of cranidium approximately 70 per cent of width across posterior limbs; longitudinal convexity moderate. Glabella as long as wide, tapered slightly anteriorly, in longitudinal profile rising abruptly above occipital furrow and sloping gently downward anteriorly; three pairs of glabellar furrows usually present but faint on specimens with test preserved, stronger on internal moulds: anterior pair frequently not visible, posterior pairs usually so, the last pair most distinct and abruptly curved backward; dorsal furrow narrower than occipital furrow, but deep and distinct throughout its course; occipital furrow wide at longitudinal axis, swings slightly back and then forward to connect with dorsal furrow, becoming deeper and narrower in so doing; occipital ring thickest at center and arched slightly backward. Border rounded in transverse profile, made distinct by a deep marginal furrow, tapered only slightly at ends; brim one and half times width of border, its convexity continuing the long downward slope of the anterior two-thirds of glabella; fixed cheeks a little less than one-third of glabella width and only slightly raised above dorsal furrow, their longitudinal convexity moderate and transverse profile flat; palpebral lobes slightly convex laterally, extending from a point lateral to mid-glabellar furrow to point lateral to most posterior one; ocular ridges strong in best preserved specimens, faint in others, oblique, originate lateral to most anterior glabellar furrow; posterior limbs wide, 70 per cent as long as width of base of glabella, broadly and deeply furrowed.

Facial suture intramarginal about halfway to center of cephalon, curves sharply around anterolateral corners of cranidium and inward to a point lateral to middle glabellar furrow, curves slightly around palpebral lobes and trends posterolaterally at an angle of 30° to 40° with longitudinal axis; opisthoparian.

Free cheeks and pygidium unknown.

Fine surface granulation may be present.

Remarks.—*Dellea wilbernsensis* is the most abundant species of the genus in the Morgan Creek member of the Wilberns limestone. The genoholotype is a beautifully preserved but somewhat undersized specimen.

Occurrence.—Abundant 30 to 45 feet above the base of the Morgan Creek member; present at a few localities in the *Irvingella* subzone. Stations 3w.4, 3w.5, 3w.8, 4w.9, 7w.2, 7w.4, 7w.8, 8w.3, 9w.12, 9w.15, 11w.7, 11w.8, 12w.11–12w.13, 12w.15, and 13w.6.

Genoholotype.—CW-48, Sta. 4w.10; paratypes CW-49 and CW-51, Sta. 12w.5, and CW.50, Sta. 11w.7, and CW-90, Sta. 7w.9.

DELLEA sp. undet.
Plate 11, figures 3, 10, 11

Several specimens are present in the writer's collection whose cranidia differ from the general pattern of *D. wilbernsensis* in having a proportionately longer glabella and a shorter radius of curvature for the frontal margin, but which are too poorly known to form any definite species. CW-52, Sta. 3w.4, CW-53, Sta. 7w.7, and CW-54, Sta. 7w.6.

Genus BERKEIA Resser 1937

BERKEIA GLABELLAMERSA Wilson, n. sp.

Plate 11, figures 13–15

Cranidium slightly longer than wide, only moderately convex. Glabella tapers anteriorly to an evenly rounded front, is almost as long as wide and of slight convexity; dorsal furrow very wide and deep, causing the low glabella to have a sunken appearance; glabella furrows oblique, moderately short and three in number, the anterior pair visible only on specimens without the test; occipital furrow deep and narrow at sides, widening slightly and becoming more shallow at center; occipital ring somewhat wider at center than on sides and arched backward slightly. Border well defined by a deep wide marginal furrow; brim convex, twice width of border, the whole frontal limb being equal to half the length of glabella; fixed cheeks rise abruptly toward palpebral lobes, are convex and at middle are almost half width of glabella; palpebral lobes long and crescent shaped, extending from a point just anterior to lateral end of middle glabellar furrow to point halfway between lateral ends of posterior glabellar and occipital furrows; ocular ridge indistinct; posterior limbs narrow, short, distinctly furrowed, and make a right angle with the longitudinal axis of cranidium.

Facial suture intramarginal halfway to center; from anterior margin curves outward to marginal furrow, whence it curves slightly inward for a short distance to anterior end of palpebral lobe, continues along palpebral lobe to its posterior end where it turns abruptly and proceeds outward.

Free cheeks and pygidium unknown.

Remarks.—Proper generic identification of this species is contingent upon distinction between *Dellea* and *Berkeia* for it possesses features in common with both. Compared with *Dellea* the latter genus has a deeper wider dorsal furrow and a more convex brim. The internal impression of *Berkeia* has deeper glabellar furrows, but when the test is preserved the furrows seem to be equally weak on representatives of both genera. While the proportions of the two genera are much the same, the cranidium of *Berkeia* is less highly arched in longitudinal profile.

Berkeia glabellamersa differs from the genotype, *B. typica*, in having a shallower dorsal furrow, probably shallower glabellar furrows, and fixed cheeks that are horizontal instead of laterally downsloping. It is placed in *Berkeia* chiefly because of its slight convexity and more sunken glabella, these characteristics as well as its wider fixed cheeks distinguishing it from any species of *Dellea*.

Occurrence.—Rare in the middle portion of the *Elvinia* zone (*Dellea-Burnetia* subzone) 30 to 45 feet above the base of the Morgan Creek limestone member of the Wilberns. Station 4w.9, 7w.7, 7w.8, 8w.4, 9w.12.

Holotype.—CW-21, Sta. 7w.8 and CW-23, Sta. 4w.9, paratype.

Genus DOKIMOCEPHALUS Walcott 1924

Original Description.—"*Dokimocephalus* is characterized by the long, pointed frontal limb, the deep dorsal and glabellar furrows and the elaborate surface ornamentation. Thorax and pygidium as yet unknown . . . ."

Remarks.—It is hoped that the rather extended specific description to follow will point out the major characteristics of the genus. As presently conceived great variation is allowed in the shape of the border which varies from spoon or spatula shaped, to nasute (as in the genotype, *D. pernasutus* Walcott), to widely expanded and attenuated. These latter forms were all included by Resser under the related genus *Burnetia*. However, in those forms identified by the writer as *Dokimocephalus* not only is the border far more extended longitudinally, but the glabella is not so elevated in transverse profile, is longer and more deeply furrowed and the occipital furrow is much shallower at the center. All of Resser's figured species having the characteristics of *Dokimocephalus* possess an occipital spine (Resser, 1942, pl. 17) whereas one is not present in *Burnetia urania* nor in any of his species closely resembling it. Of the ten species described by Resser (1942, pp. 80–84), *Burnetia intermedia*, *B. extensa*, *B. curta*, and *B. lingula* belong to the genus *Dokimocephalus* and *Burnetia edwardsi* is an excellent example of the genus *Wilbernia*.

DOKIMOCEPHALUS INTERMEDIUS (Resser)
Plate 9, figures 1, 2, 4, 5

Burnetia intermedia RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 80, pl. 17, figs. 10, 11.

Burnetia lingula RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 82, pl. 17, figs. 32, 33.

Burnetia extensa RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 81 (pars), pl. 17, figs. 15–18, 20.

Dokimocephalus intermedius (Resser) FREDERICKSON, 1948, Jour. Paleontology, vol. 22, no. 6, p. 801.

Supplementary Description.—Cranidium large, averaging about 20 mm. for both dimensions, slightly longer than wide, of moderate convexity. Glabella slightly longer than wide, prominent, greatly elevated above dorsal furrow, somewhat tapered, rounded, and depressed anteriorly; dorsal furrow very deep laterally, becoming shallow in front although still well incised at the anterolateral corners of glabella; three pairs of glabellar furrows present: anterior pair barely visible, but posterior pairs wide, deep, long, and strongly oblique; occipital furrow exceedingly strong at sides, shallow at center; occipital ring arched forward laterally and extended at center into a long spine that rises above horizontal at a 30° angle and whose length is about equal to that of the glabella. Border concave, its posterior portion continuing the downward slope of the anterior part of glabella and preglabellar area, length about equal to that of glabella, its greatest width along shallow marginal furrow, gradually narrowing anteriorly, the frontal margin absent on all specimens available; brim reduced to a narrow band in front of glabella, widens and is greatly depressed laterally; fixed cheeks one-third width of glabella, depressed longitudinally in both directions, but in transverse profile rise gradually from dorsal furrow and become horizontal near their lateral edges; palpebral lobes small and crescent-shaped, about half as wide as fixed cheeks along transverse median line, separated from inner fixed cheeks by a distinct furrow, and extended from a point just anterior to lateral termination of posterior-most pair of glabellar furrows to a point lateral to the occipital furrow; ocular ridge fairly distinct and very oblique; posterior limbs narrow, straplike, extended at right angles to longitudinal axis, moderately depressed, and deeply furrowed.

Facial suture missing at its anterior extremity on specimens available; proceeds posteriorly along anterolateral margin of the border, curves evenly outward just before reaching the lateral extremity of the marginal furrow, passes slightly inward from this point to anterior end of palpebral lobe around which it circles before extending abruptly outward along posterior limbs.

Free cheeks unknown.

Pygidium of moderate size, semi-ellipsoidal in general outline; lateral third of anterior pleural margin deflected posterolaterally at 45° angle; anterolateral corners rounded, posterolateral corners sharp where deflected portion of anterior margin joins wide arc of posterior margin. Axis stands well above pleural lobes, extends two-thirds length of pygidium, and possesses three rings and a terminal segment; pleural lobes wide, slope gently down to border, traversed by two segments with secondary furrows that form four ridges on each lobe parallel to course of anterior margin; pleural margin moderately wide, unsegmented, and bears a narrow but elevated border that seemingly thickens anteriorly.

Cranidium strongly pustulose except on border; pygidium pustulose on its axial rings.

Remarks.—A well preserved pygidium (pl. 9, fig. 5) was associated with cranidia of *Dokimocephalus intermedius* and *Burnetia urania* and several other species which were eliminated because of size and lack of surface granulation. The pygidium was assigned to *D. intermedius* rather than to *Brunetia urania* because the former species is the more common in the *Elvinia* zone, and because at another locality a fragment of a similar pygidium was associated with several cranidia of *D. intermedius*.

Occurrence.—Moderately abundant in the middle portion of the *Elvinia* zone of the Morgan Creek limestone member, first appearing about 30 feet above its base, seemingly absent in the *Irvingella* subzone. Stations 3w.4, 3w.8, 4w.9, 4w.10, 7w.11, 8w.3, 8w.4, 12w.3, 12w.5, 12w.10, 12w.12, 13w.6, 13w.9, 13w. 11.

Hypotypes.—CW-11 and CW-14, Sta.

12w.5; CW-13 and CW-16, Sta. 8w.3; CW-15 (pygidium), Sta. 3w.4.

Genus ELVINIA Walcott 1924
ELVINIA ROEMERI (Shumard)
Plate 10, figures 5, 9, 10, 12, 13

Dikelocephalus roemeri SHUMARD, 1861, Am. Jour. Sci., 2nd ser., vol. 32, pp. 220, 221.
Elvinia roemeri (Shumard) WALCOTT, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 56, pl. 11, fig. 3.
Elvinia roemeri (Shumard) BRIDGE, 1937, U. S. Geol. Survey, Prof. Paper 186-M, pp. 251–255, (complete synonymy to date, full discussion of species), pl. 69, figs. 1–21.

Remarks.—Although Resser (1937, p. 12; 1938, pp. 30–33; 1942, pp. 94–99) has identified fourteen species of the genus *Elvinia*, Bridge (1937, p. 254) and Frederickson (written communication) have pointed out that various ontogenetic stages of *Elvinia roemeri* may easily be mistaken for different species. Believing this true and subscribing to the tenet that multitudes of new species are valueless unless of stratigraphic significance, all the Texas material has been identified as *Elvinia roemeri*.

Occurrence.—Elvinia roemeri is by far the best index species to the Ironton fauna. It is the largest and most abundant species of the fauna in Texas. It is present but not common in the Welge member and lower portion of the Morgan Creek limestone, most abundant in the *Dellea-Burnetia* subzone 30 to 45 feet above the base of the Morgan Creek and present at one locality in the *Irvingella* subzone, 6 feet below the base of the *Eoörthis-Billingsella* bed. Stations 2w.2, 2w.4, 2w.7, 2w.8, 3w.2–3w.4, 3w.8, 3w.10, 4w.7, 4w.9, 4w.10, 6w.1, 6w.4, 7w.2, 7w.4, 7w.7, 7w.8, 7w.10, 7w.11, 8w.2, 8w.3, 9w.1, 9w.5–9w.7, 9w.9, 9w.12–9w.14, 10w.6, 10w.7, 11w.6–11w.9, 11w.13, 12w.2, 12w.3, 12w.5, 13w.1, 13w.13–13w.9, 13w.11.

Hypotypes.—CW-44, Sta. 10w.6; CW-47, Sta. 3w.2; CW-46 (pygidium), Sta. 13w.6, CW-45 (free cheek), Sta. 12w.4.

Genus IDDINGSIA Walcott 1924
IDDINGSIA NEVADAENSIS Resser
Plate 9, figures 6–8, 19

Iddingsia nevadaensis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 85, pl. 16, figs. 15–17.

Supplementary Description.—Cranidium large and very convex. Glabella large, long, highly arched, untapered but rounded anteriorly, its frontal half sloping steeply downward; dorsal furrow deep; two pairs of glabellar furrows present: anterior pair short, distinct, and slightly oblique; posterior pair much deeper, longer, and deflected backward; occipital furrow deep and wide, more incised laterally than at center; occipital ring slightly tapered laterally and arched forward. Border as wide as brim, untapered and flat, well defined by a wide marginal furrow, its anterior margin describing a wide arc; brim continuing the steep downward slope of the anterior portion of the cranidium, everywhere of equal width, the border and brim together accounting for one-third total length of cranidium; fixed cheeks at widest point about one-third width of glabella, slope up steeply from dorsal furrow; palpebral lobes as long as border is wide, elevated above fixed cheeks, widely crescent-shaped, extend from opposite occipital furrow to a point midway between glabellar furrows, separated from fixed cheeks by broad furrows; ocular ridges faint and very oblique; posterior limbs narrow and moderately depressed, extended at right angle to longitudinal axis, broadly and deeply furrowed, lateral extremities unknown.

Facial suture indents sharply at lateral extremity of marginal furrow, bows outward a short distance before again indenting anterior to palpebral lobe, curves around palpebral lobe, and proceeds outward.

Pygidium semi-ellipsoidal in outline; anterior margin curved gently posteriorly to meet wide arc of posterior margin at rounded corners lateral to middle axial ring; axis prominent, extends almost to posterior margin, possesses three strong rings and a large terminal segment; pleural lobes wider than axis, each made up of two strongly defined segments, slope posterolaterally to a flat, moderately wide unsegmented marginal portion; border unknown, possibly absent along posterior margin, prominent anterior to lateral corners.

Remarks.—All specimens found are fragmentary. Two pygidia were closely associated with a cranidium at a station (8w.2) that produced no other fossils except *El-*

vinia roemeri (Shumard). The pygidium resembles that of *E. roemeri*, but is wider and has a relatively narrower axis. Resser (1942, p. 85) has pointed out the differences between *I. nevadaensis* Resser and *I. robusta* (Walcott).

Occurrence.—Rare in the lower portion of the *Elvinia* zone, 15 to 30 feet above the base of the Morgan Creek member where it is associated with *Kindbladia wichitaensis* (Resser) and *Plataspella anatina* (Resser). Station 3w.2, 8w.2, 9w.10.

Hypotypes.—CW-27, Sta. 3w.2, CW-28 and CW-29, Sta. 8w.2.

Genus IRVINGELLA Ulrich and Resser 1924

IRVINGELLA BURNETENSIS Resser

Plate 11, figures 18, 21

Irvingella burnetensis RESSER, 1942, Smithsonian Misc. Coll. vol. 103, no. 5, p. 20, pl. 3, figs. 28–33.

Cranidium very convex, of moderate size, and with a width of over 10 mm., not quite twice the length. Glabella very large, its front rounded, highly arched transversely over fixed cheeks, longitudinally rising gradually above occipital furrow for some distance, then sloping abruptly downward anteriorly; glabellar furrows two in number: anterior pair faint, short and straight, posterior pair deep, oblique, and connected across the middle of glabella by a straight deep depression; occipital furrow deep and wide; occipital ring thick, narrowing only slightly at sides. Border non-tapered, defined by a faint marginal furrow, forms a straight bar across anterior end of cranidium; brim absent; fixed cheeks at widest point one-third width of glabella at base, narrow slightly posteriorly, and narrow anteriorly to one-half of greatest width, merge with border on either side of glabella, arch gently, slope laterally downward from glabella and are abruptly bent downward anteriorly; palpebral lobes depressed, long and narrow, extend almost whole length of fixed cheeks, directed posterolaterally from border to transverse median line at which point they turn to proceed directly posteriorly to a point lateral to occipital furrow, where they terminate; ocular ridges absent; posterior limbs very short, straight, hardly distinct from fixed cheeks, traversed by a wide deep furrow.

Facial suture originates at anterolateral corner of cranidium, trends posterolaterally along margin of palpebral lobe to transverse median line, thence passes slightly inward, making a wide curve before turning outward a very short distance along margin of small posterior limbs.

Free cheek and pygidium unknown.

Remarks.—*Irvingella burnetensis* differs from the small *I. media* Resser only in having narrower fixed cheeks and in being considerably more depressed anteriorly. It seems possible that *I. media* Resser may be merely a juvenile form of the former species, but the forms are described separately until more material is examined. Resser has described seven other species from the lower Wilberns limestone of Texas (1942, pp. 17, 18, 20, 21). The writer considers most of these to have the same basic characteristics as *I. burnetensis*.

Occurrence.—Rare in the middle *Elvinia* zone, 30 to 45 feet above the base of the Morgan Creek member of the Wilberns limestone. Extremely abundant in the *Irvingella* subzone, 1 to 5 feet below the *Eoörthis-Billingsella* bed. Stations 4w.11, 7w.12, 8w.5, 9w.9?, 9w.13?, 9w.14?, 9w.15, 10w.7?, 10w.8, 10w.9?, 12w.2, 12w.13, 12w.14.

Hypotypes.—CW-1 and CW-2, Sta. 4w.11.

IRVINGELLA MEDIA Resser

Plate 10, figure 7; Plate 11, figures 16, 17, 19, 20

Irvingella media RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 22, pl. 3, figs. 46–54.

Cranidium small and convex with a width of about 6 mm. and a length less than two-thirds width. Glabella, dorsal and glabellar furrows, occipital rings and furrow as in *Irvingella burnetensis*. Border thin, non-tapered, defined by a faint marginal furrow, and forms a straight bar across anterior end of cranidium; brim absent; fixed cheeks at widest point half width of glabella at its base, narrow slightly posteriorly, narrow anteriorly to one-third greatest width, merge with border on either side of glabella, arch gently, and slope laterally downward from glabella; palpebral lobes very long and

narrow, depressed, separated from fixed cheeks by distinct furrows, extend from point just in front of lateral extremity of anterior-most glabellar furrow almost to occipital furrow, trend posterolaterally for anterior two-thirds of this length, then proceed straight back, widen gradually posteriorly; ocular ridges absent; posterior limbs as in *I. burnetensis*.

Facial suture as in *I. burnetensis*.

Free cheeks unknown.

Pygidium approaches a semicircle in outline, although its anterior margin is straight enough to give it a spade-like appearance, axis occupies about two-fifths total width of pygidium and three-fifths total length, stands extremely high and possesses two large rings and a terminal segment; pleural segmentation absent, the smooth pleural platform possessing a well defined and thickened border that in some specimens is flat-lying, but in others rises at anterolateral corners to give it an undulating appearance. A pygidial mold (pl. 10, fig. 7) leaves the impression that the anterolateral corner is prolonged into an anteriorly directed spine; other material in the collection fails to substantiate this, however. There can be no doubt that this rather distinctive pygidium belongs to the *Irvingella* cranidium. The writer has found it only in the *Irvingella* subzone coquina and it is present in Wisconsin collections as well as those from Texas.

Occurrence.—Rarely present in the middle *Elvinia* zone, 30 to 45 feet above the base of the Morgan Creek member, abundant in the *Irvingella* subzone. 1 to 5 feet below the *Eoörthis-Billingsella* bed. Stations 4w.8, 7w.4, 9w.15, 12w.2, 12w.3, 12w.14.

Hypotypes.—CW-4, CW-5, CW-6 (pygidium), Sta. 12w.13; CW-3 (pygidial mould), Sta. 12w.14.

Genus KINDBLADIA Frederickson 1948
KINDBLADIA WICHITAENSIS (Resser)
Plate 9, figures 14–18

Berkeia wichitaensis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 92, pl. 15, figs. 31–33.

Kindbladia wichitaensis (Resser), FREDERICKSON, 1948, Jour. Paleontology, vol. 22, no. 6, pl. 123, figs. 20–23.

Supplementary Description.—Cranidium convex, rather small, slightly wider than long. Glabella prominent, longer than wide, tapered anteriorly to almost half its width at base; dorsal furrow extremely wide and deep, giving the glabella a sunken appearance; three pairs of glabellar furrows present, but the anterior pair rarely visible, posterior pairs deeply incised, oblique, and progressively longer, the posterior-most pair reaching almost to the center and turning from its oblique course to curve more

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EXPLANATION OF PLATE 11

FIGS. *1, 2, 4–7, 12—Dellea wilbernsensis* Wilson, n. sp. *1, 2*, Paratype; dorsal and profile view of large cranidium, ×2, CW-49, Sta. 12w.5. *4, 5*, Holotype: dorsal and profile view, ×2, of small cranidium, CW-48, Sta. 4w.10. *6*, Paratype; dorsal view, ×2, of moderate sized cranidium, CW-51, Sta. 12w.5. *7*, Paratype; dorsal view, ×2, of moderate sized cranidium with smaller cranidium of same species, CW-50, Sta. 11w.7. *12*, Hypotype; dorsal view, ×2, of large poorly preserved cranidium, CW-90, Sta. 7w.9. (p. 35)

8, 9—Ptychopleurites amploöculata Frederickson. *8*, Hypotype; dorsal view, ×4, of fragmentary cranidium, CW-60, Sta. 4w.11. *9*, Hypotype; dorsal view, ×4, of fragmentary cranidium, CW-59, Sta. 8w.5. (p. 42)

3, 10, 11—Dellea sp. undet. *3*, dorsal view, ×2, of cranidium CW-54, Sta. 7w.6. *10*, dorsal view, ×2, of cranidium CW-53, Sta. 7w.7. *11*, dorsal view, ×2, of cranidium CW-52, Sta. 3w.4. (p. 35)

13–15—Berkeia glabellamersa Wilson, n. sp. *13*, Paratype; dorsal view of cranidium, ×3, CW-23, Sta. 4w. 9. *14, 15*, Holotype; dorsal and profile views, ×3, of cranidium, CW-21, Sta. 7w.8. (p. 36)

16, 17, 19, 20—Irvingella media Resser. *16*, Hypotype; dorsal view, ×3, of moderate sized cranidium, CW-5, Sta. 12w.13. *17*, Hypotype; moderate sized pygidium, ×3, CW-6, Sta. 12w. 13. *19, 20*, Hypotype; dorsal and profile views, ×3, of moderate sized cranidium, CW-4, Sta. 12w.13. (p. 39)

18, 21—Irvingella burnetensis Resser. *18*, Hypotype; profile view, ×2, of moderate sized cranidium, CW-2, Sta. 4w.11. *21*, Hypotype; dorsal view, ×2, of moderate sized cranidium, CW-1, Sta. 4w.11. (p. 39)

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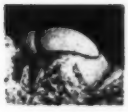

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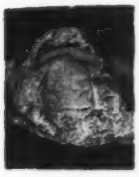

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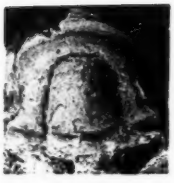

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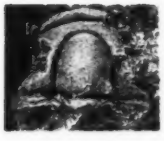

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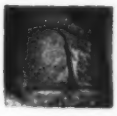

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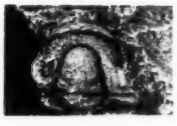

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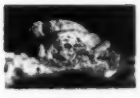

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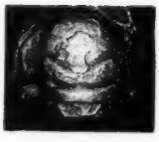

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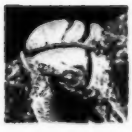

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Wilson, *Elvinia* Zone Trilobites from Texas

strongly backward in so doing; occipital furrow deep laterally, wider and shallower at center; occipital ring about the same width laterally as the border, thickens toward center and rises to a posteriorly directed protuberance; border slightly wider at center than laterally, its anterior margin more often angular than evenly curved; brim convex and over twice width of border; fixed cheeks high and narrow, less than one-third width of glabella, and in transverse profile flat-topped but greatly depressed both anteriorly and posteriorly; palpebral lobes unknown; ocular ridge absent; posterior limbs long and narrow, curved slightly backward and traversed by a deep broad furrow.

Facial suture intramarginal almost to center; from the anterior corners proceeds directly backward and makes a slight indentation at a point opposite the lateral extremity of the middle glabellar furrow; course around palpebral lobes unknown; halfway between posterior-most glabellar and occipital furrows it proceeds outward at an angle of about 80° with the longitudinal axis; opisthoparian.

Remarks.—Of Resser's species of *Berkeia* (1942, pp. 90–94) the writer considers the following to belong in E. A. Frederickson's genus *Kindbladia: Berkeia comes, B. retusa, B. wichitaensis, B. angustata, B. jucunda,* and *B. missouriensis.* This group of species differs from the genotype, *Berkeia typica,* in having a less elevated glabella, narrower fixed cheeks, and a more angular and less widely arcuate border. In the writer's opinion the genus *Kindbladia* is related to *Iddingsia* as represented by the genotype *Iddingsia similis.*

Occurrence.—Originally described from the Honey Creek limestone of the Wichita Mountains, Oklahoma. Abundant in the basal 35 feet of the *Elvinia* zone of the Morgan Creek member of the Wilberns limestone in Texas. One poor specimen possibly representing the species was found in the Welge sandstone member. The species is absent in the upper part of the *Elvinia* zone. Stations 2w.1, 4w.1?, 4w.6, 7w.2, 7w.4, 7w.6, 8w.2, 9w.3–9w.11, 10w.6, 10w.7, 12w.1, 12w.2, 12w.5, 12w.8, 13w.2, 13w.3, 13w.7?.

Hypotypes.—CW-17, Sta. 12w.2; CW-18, Sta. 10w.7; CW-19, Sta. 9w.4; CW-20, Sta. 8w.2.

Genus PLATASPELLA Wilson, n. gen.

Cranidium large (30 mm. by 23 mm.), wider than long, its anterior end moderately depressed. Glabella only slightly tapered, rounded in front, transversely convex, its posterior end standing high above fixed cheeks, its anterior end sloping evenly down in longitudinal view; dorsal furrow deep and wide along sides, becoming less distinct in front of glabella; glabellar furrows three in number, long, faint (often not visible), and all curved posteriorly; occipital furrow shallow but wide; occipital ring parallel-sided, arched backward and frequently bearing a long spine that rises at about a 15° angle. Border slightly concave, crescent-shaped, its width equal to or greater than that of the brim, marginal furrow so wide that often it is difficult to separate border and brim; brim wide and together with border equal to length of glabella, a slight preglabellar swelling noticeable on some specimens, but generally its convexity continues the gentle slope of the anterior part of the glabella; fixed cheeks from one-third to half as wide as glabella, slope gently upward from dorsal furrow; palpebral lobes curved strongly outward, situated opposite posterior-most pair of glabellar furrows, separated from the outbowing fixed cheeks by a distinct furrow; ocular ridges prominent, originating opposite anterior pair of glabellar furrows; posterior limbs long and narrow, extended straight out from longitudinal axis and traversed by a wide furrow.

Facial suture intramarginal almost to center of cranidium, rounds anterior corners and proceeds slightly inward to a point anterior to palpebral lobes whence it proceeds sharply outward, bends around palpebral lobes, indents again posterior to the lobes and passes straight outward; opisthoparian.

Surface of brim and border marked by fine anastomosing lines running in longitudinal direction.

Free cheeks and pygidium unknown.

Remarks.—Of Resser's species of *Iddingsia* (1942, pp. 87–90) the following forms may be certainly included in *Plataspella: I. bicincta, I. crassimarginata, I. alpersensis, I. anatina,* and *I. simplicitas. Plataspella* is similar to *Iddingsia* in possessing a strong ocular ridge, posteriorly located palpebral lobes, strap-like posterior limbs, and in gen-

eral glabellar shape. It differs in having a much more flattened and laterally expanded border and brim which lack the convexity of those of *Iddingsia*. The marginal furrow is wide and shallow and in Texas and Oklahoma species the glabellar furrows are very faint. The occipital ring of *Plataspella* often bears a spine, which is not the case in *Iddingsia*. The writer believes that more intensive study of the National Museum collections will disclose transitional forms between the two genera. *Plataspella* is a good marker for the Ironton, being known to the writer in collections from Wisconsin, Pennsylvania, Oklahoma, Missouri, and Texas.

Genotype: *Iddingsia anatina* Resser 1942.

PLATASPELLA ANATINA (Resser)
Plate 9, figures 20–22, 25, 26

Iddingsia anatina RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 89, pl. 17, figs. 1, 2.

Iddingsia alpersensis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 88, pl. 16, figs. 33–38.

Iddingsia simplicitas RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 89, pl. 17, figs. 3–9.

Remarks.—Resser's three descriptions are deemed sufficient. His three Oklahoma species of *Iddingsia* which the writer considers to belong to *Plataspella* seem indistinguishable except for a slight difference in length of the palpebral lobes, a minor difference in preglabellar swelling, and in the flaring of the brim and border. The writer does not consider the material complete enough to safely designate species on this latter characteristic. The Texas material closely resembles the Oklahoma forms except that half of the Texas forms have no occipital spine. What Roemer described from Camp San Saba, Texas (42-13-w) in 1849 as a pygidium of an unknown trilobite genus and what Bridge reillustrated and termed *Idahoia?* sp. (1937, p. 256, pl. 69, figs. 27, 28) is in all probability a fragmentary cranidium of *Plataspella anatina*.

Occurrence.—In Texas found in the basal 35 feet of the *Elvinia* zone of the Morgan Creek member. In some places it is very abundant and is the most prominent species of the lowest *Elvinia* subzone. It is associated with *Iddingsia nevadaensis* and *Kindbladia wichitaensis*. Stations 2w.1–2w.5, 7w.3, 9w.4–9w.7, 9w.11, 9w.13, 12w.1, 12w.2, 12w.7, 13w.1.

Genoholotype.—U. S. Nat. Mus. No. 108803 from Honey Creek limestone (loc. 9q), Blue Creek Canyon, Wichita Mountains, Oklahoma, hypotype from Texas: CW–24, Sta. 2w.4; fragmentary cranidia not safely identifiable: CW–25, Sta. 2w.5 and CW–26, Sta. 12w.2.

Genus PTEROCEPHALIA Roemer 1849
PTEROCEPHALIA SANCTISABAE Roemer
Plate 10, figures 1–3

Pterocephalia sanctisabae ROEMER, 1849, Texas, p. 421.

Pterocephalia sanctisabae ROEMER, 1852, Die Kreidebildungen von Texas, p. 92, pl. 11, figs. 1a–d.

Pterocephalia sanctisabae Roemer, BRIDGE, 1937, U. S. Geol. Survey, Prof. Paper 186-M, pp. 246–250 (complete synonymy to date, translation of Roemer's description, discussion of species and genus), pl. 67, figs. 1a–d; pl. 2, figs. 9–13.

Remarks.—Although the specimens collected from the Morgan Creek member by the writer are fragmentary, Bridge's excellent description and the distinctive character of the species make its identification certain.

Occurrence.—Present but not common in the middle portion of the *Elvinia* zone, 30 to 50 feet above the base of the Morgan Creek member of the Wilberns limestone. Stations 3w.3, 3w.8, 8w.3, 9w.11, 12w.5, 12w.11, 13w.6, 13w.7.

Hypotypes.—CW–55, Sta. 13w.6; CW–57, Sta. 13w.7; CW–56 (pygidium), Sta. 12w.11.

Genus PTYCHOPLEURITES Kobayashi 1936
PTYCHOPLEURITES AMPLOOCULATA Frederickson
Plate 10, figure 4; Plate 11, figures 8, 9

Ptychopleurites amploöculata FREDERICKSON, 1948, Jour. Paleontology, vol. 22, no. 6, p. 803, pl. 123, figs. 9–11.

Supplementary Description.—Cranidium convex, very small, being about 3 by 4 mm., slightly wider than long, but if posterior limbs are excluded its length is about twice its width. Glabella long, two-thirds total length of cranidium excluding occipital ring, very convex almost tumid, abruptly depressed anteriorly; dorsal furrow deep and

narrow at sides, becoming more shallow in front of glabella; three pairs of weak glabellar furrows becoming progressively deeper, longer, and more oblique posteriorly; occipital furrow deep at sides. Border flat, twice width of brim, only slightly tapered at sides, its anterior margin arcuate; brim extremely narrow anterior to glabella, widening laterally, slopes steeply up from distinct marginal furrow and flat border; fixed cheeks narrow, greatly constricted in width at point lateral to anteriormost pair of glabellar furrows, expanded posterior to this point, bowed outward, constricted again at point lateral to occipital furrow; palpebral lobes elongated, crescent-shaped, wider than inner fixed cheeks from which they are separated by a distinct groove, proceed from the anterior to the posterior constriction of the fixed cheeks; ocular ridges short and faint; posterior limbs very long and narrow, extend at right angles to longitudinal axis, traversed by a distinct furrow.

Facial suture intramarginal to center, evenly rounds anterolateral corners of cranidium and is directed sharply inward at a point lateral to anterior-most pair of glabellar furrows, whence it proceeds widely around edge of long palpebral lobe to indent again at lateral extremity of occipital furrow, and proceed outward at right angles to longitudinal axis.

Free cheek unknown.

Associated pygidium semielliptical in outline, strongly convex, axis long, extends to border and stands well above pleural lobes, tapered posteriorly to about half its width at anterior margin, and marked by three strongly defined rings and a terminal segment; pleural lobes very convex, highly elevated above border, three interpleural grooves and each segment marked by a pleural furrow, marginal furrow indistinct, lateral width of border equal to that of pleural platform, narrows centrally because of indentation of its margin at the longitudinal axis, and continues the steep downward slope of the pleural lobes though not so abruptly.

Remarks.—The genus *Ptychopleura* Kobayashi 1936 was changed by its author the same year to *Ptychopleurites*, Kobayashi having found the former name preempted (1936a, p. 922, note 2). As stated by Frederickson *Ptychopleurites amploöculata* differs from *P. brevifrons* Kobayashi (genotype) in having narrower posterior limbs and large, more posteriorly located palpebral lobes. The pygidium described above agrees in size with associated cranidia of the species, and is referred to *P. amploöculata* because on the basis of known species of comparable size in the *Irvingella* subzone this is the only species to which it might belong.

Occurrence.—Restricted to the *Irvingella* subzone, 1 to 3.5 feet below the highest range of *Elvinia* in both the Wilberns limestone of Texas and the Honey Creek limestone of Oklahoma. It is moderately abundant in the Morgan Creek member of the Wilberns and is associated with species of *Irvingella* and *Sulcocephalus*. Stations 4w.11, 7w.12, 8w.5, 9w.14, 10w.8, 12w.13, 12w.14.

Hypotypes.—CW-58a (pygidium) and CW-58b, Sta. 12w.14; CW-59, Sta. 8w.5; CW-60, Sta. 4w.11.

Genus XENOCHEILOS Wilson, n. gen.

Cranidium small, highly convex, quadrate in shape if the genal spine is excluded. Glabella long and sunken, parallel-sided, sharply crested, highest at occipital ring; three pairs of oblique glabellar furrows present; occipital furrow faint at center, distinct at sides; occipital ring parallel-sided. Definite border and marginal furrow absent; brim wide, and from an anterior concave portion rises steeply to near the dorsal furrow; fixed cheeks as wide as glabella, strongly elevated laterally, palpebral lobes unknown; posterior limbs greatly depressed, traversed by a wide deep furrow, and extended far outward and backward.

Facial suture proceeds posteriorly without indentation from anterolateral corners of cranidium to a point lateral to outer end of ocular ridge, course around palpebral lobes unknown, proceeds posteriolaterally and appears to cut margin of cephalon about at genal angle.

Genotype: *Xenocheilos minutum* Wilson n. sp.

Remarks. Xenocheilos resembles *Pterocephalia* Romer in its wide fixed cheeks, sharply crested and sunken glabella, and oblique, well defined glabellar furrows. It is, however, only one-sixth the size of *Pterocephalia* and

differs from it in all respects save those mentioned.

XENOCHEILOS MINUTUM Wilson n. sp.
Plate 9, figures 11–13

Cranidium small, being about 4 by 5 mm. in size, slightly wider than long, highly convex, quadrate in shape excluding posterior limbs. Glabella long and sunken, parallel-sided, evenly rounded and sloping gently downward anteriorly, convex and sharply crested in transverse profile; dorsal furrow wide and deep; anterior pair of glabellar furrows barely visible, two posterior pairs distinct, short and slightly oblique; occipital furrow much deeper at sides than at center; occipital ring straight and parallel-sided. Definite border and marginal furrow absent, the anterior border of the cranidium being slightly concave extension of the wide brim which rises steeply at a 45° angle to the preglabellar area, and then slopes down to the dorsal furrow; fixed cheeks as wide as glabella, rise gradually from the dorsal furrow, their lateral edges being almost as elevated as the dorsal surface of the glabella; palpebral lobes unknown; ocular ridges wide and very distinct, slightly oblique, originating lateral to anterior pair of glabellar furrows; posterior limbs narrow, greatly depressed, traversed by a wide deep furrow that widens laterally, and extended far outward and gently backward.

Facial suture proceeds posteriorly without indentation from anterolateral corners of cranidium to a point lateral to outer end of ocular ridge, course around palpebral lobes unknown, proceeds posterolaterally and appears to cut the margin of the cephalon at the genal angle.

Occurrence.—Rare in the *Elvinia* zone. Two specimens found at different localities, each about 30 feet above the base of the Wilberns limestone. Stations 9w.9 and12w.2.

Genoholotype.—CW-62, Sta. 12w.2; paratype CW-61, Sta. 9w.9

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THE ORDOVICIAN TRILOBITE *EOBRONTEUS*

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ABSTRACT—This genus is found in the Middle Ordovician of North America and the Upper Ordovician and basal Silurian of Europe. Twelve species are recognized, of which four are new. A new family, Eobronteidae, is proposed to replace Scutellidae Richter & Richter, non Agassiz.

INTRODUCTION

Ordovician trilobites referable to *Scutellum* in a wide sense (*Bronteus, Goldius* auct.) have been reported from a number of localities in America, but the usual fragmentary nature of the specimens and the meager information available about the first described, *Bronteus lunatus* Billings, has discouraged their study. Most references in the literature are unsupported by figures, or have only a copy of Billings' original woodcut. The present paper summarizes the described species, and adds others which the writer has encountered. There has been no systematic attempt to bring together all the American material, although it is obvious from the lists in the literature that there are other undescribed forms.

I am indebted to Dr. W. A. Bell, Geological Survey of Canada, Dr. Madeleine A. Fritz, Royal Ontario Museum of Palaeontology and Dr. J. Marvin Weller and M. S. Chappars of Walker Museum for permission to study specimens in their care. With two exceptions the photographs were made by Charles Corke of London, Ontario, under my direction.

Family EOBRONTEIDAE, new family

The generic names *Bronteus* Goldfuss 1843, and *Goldius* de Koninck 1841, have now been generally abandoned in favor of the earlier name *Scutellum* Pusch 1833, and the latter is being accepted as the correct one for these trilobites. However the change creates an awkwardness concerning the name for the family to which the trilobites belong. Scutellidae has been proposed by R. & E. Richter (1925, p. 239) and used by Prantl & Přibyl (1946, p. 4) but the same name is well established for a family of echinoids centering around the genus *Scutella* Lamarck, as has been pointed out by Poulsen (1934, p. 27) and others.

To avoid this ambiguity I suggest the familial name Eobronteidae for the trilobites. The family will include *Eobronteus* Reed, *Scutellum* Pusch, *Thysanopeltis* Hawle & Corda 1847, *Paralejurus* Hawle & Corda 1847 and *Kolihapeltis* Prantl & Přibyl 1946.

Genus EOBRONTEUS Reed 1928

Bronteus (*Eobronteus*) REED 1928, pp. 58, 75.
Bronteus, Goldius, Scutellum, auct, e. p.

Genotype: *Entomostracites laticauda* Wahlenburg 1818.

Reed erected *Eobronteus* as a subgenus of *Bronteus*, for early species differing from other Bronteidae in the uniform possession of six pairs of lateral ribs on the pygidium, and in having isolated pits representing the lateral glabellar furrows. He later (Reed 1931, p. 13) referred to *Eobronteus* as a subgenus of *Scutellum.*

The genus ranges from the Middle Ordovician to the earliest Silurian and seems to occur only in North America and northwestern Europe. The distribution is peculiar in that the genus is not known in America after the Trenton, and first appears in Europe in the Upper Ordovician (Craighead limestone, see Reed 1935 for discussion of the age of this horizon). This pattern can of course be duplicated in examples from other groups.

The species are:

Black River, Quebec.....*E. benoratus* Sinclair
Kimmswick, Missouri etc...*E. slocomi* (Bradley)
Lower Trenton, Quebec.....*E. curtus* Sinclair
Middle Trenton, Quebec etc..*E. reedi* Sinclair
E. lunatus (Bllings)
E. sculptus Sinclair

Upper Ordovician, Ireland.....
.....*E. hibernicus* (Portlock)
Upper Ordovician, Scotland. *E. grayi* (Reed)
E. craigensis (Reed)
E. lamonti Reed
Lyckholm, Esthonia etc. *E. insularis* (Eichwald)
Boda, Sweden etc.....*E. laticauda* (Wahlenburg)

Of these species only *E. lunatus* and *E. slocomi* are represented by fairly complete specimens. *E. grayi*, *E. craigensis*, *E. hibernicus* and *E. insularis* are known only from pygidia. *E. lamonti* from a cranidium.

Generic description

Cranidium.—The head is gently convex, or almost flat. The glabella is prominent, bounded by clear, although shallow, dorsal furrows which are parallel or converge for about one-third their course forward, then turn rather sharply out. They may continue to the intramarginal furrow, but may become obsolete or be continuous with the cheek furrow. The lateral glabellar furrows are obsolete or represented only by very shallow depressions, usually removed from the dorsal furrows, and transversely ovate in shape. The glabella is sharply raised posteriorly in some species, rather evenly convex behind in others.

The neck furrow is usually shallow, frequently unconnected with the dorsal furrows. The neck ring is rather short, and wider than the posterior part of the glabella, since the dorsal furrows cross it obliquely.

The fixed cheeks are usually convex, wide, the anterior portion formed by a flat or gently concave band which narrows in front of the glabella, or even disappears leaving a convex curve from the top of the glabella forward. The palpebral lobes are large, set well out from the glabella and rather far back; they are sharply protuberant due to the strong sinuosity of the facial sutures. The pleuro-occipital ring is very wide, usually resembling the first thoracic pleura in width and general shape. There is no pleuro-occipital furrow as such. The paraglabellar lobes are small but usually definite, elongately elliptical in shape, and a little convex.

The cheeks are marked by the following furrows, besides others noted in specific descriptions: (a) an intramarginal furrow of varying strength, (b) a cheek furrow which runs from the level of the first glabellar lobe parallel to the intramarginal furrow, (c) a furrow from the postero-distal corner of the paraglabellar lobe obliquely back and out along the pleuro-occipital ring.

Terrace lines are usually numerous and strong. In general they are parallel to the anterior margin on the frontal lobe of the glabella, perpendicular to this margin on the fixed cheeks in front of the cheek furrow, roughly concentric on the neck of the glabella, and concentric about the eye on the fixed cheek proper. There is a good deal of variation which is noted under the species. More specimens are needed to confirm or reject my impression that the pattern of these lines is of taxonomic importance, or, better, that it is of taxonomic convenience, reflecting in a measurable way differences which are of real importance but intangible.

Free cheeks are known only in *E. lunatus* and *E. laticauda*. In the former they are wide, concave or flat, with broad spines extending to the pygidium. This may be taken as typical of the genus, as apparently Warburg's material was fragmentary, and her figure 8 is a restoration. The cheeks of *E. lunatus* have been described in detail by Wilson (1948).

The *labrum* is known only in *E. lunatus* and *E. laticauda*, q.v. In general it is shield-shaped, with an entire border and prominent maculae.

Thorax.—There are ten segments in the thorax. The rhachis is well raised, the rings simple, flat on top (lengthwise), each distinctly overlapping the next posterior ring for about one-fifth its length. The articulating surface is formed by a posterior doublure of corresponding length. The dorsal furrows are shallow, converging in front and behind in *E. lunatus*, but essentially parallel in *E. sculptus*. The pleurae are simple, flat, bent down gently and a little back at about two-thirds their width; they have parallel sides except that the points are directed a little back.

The terrace lines are convex forward on the rhachis. Those on the pleurae differ so much in the two species showing them (*E. lunatus* and *E. sculptus*) that no generalization can be made.

Pygidium.—This is flat to depressed-convex. Its outline varies from semicircular to semi-elliptical; the anterior margin is transverse, but the rhachis may project

slightly in the middle. The rhachis is variably developed; it may be prominently raised or inconspicuous; it is undefined behind or obscurely marked off by a change in curvature; there may be traces of rhachial rings, but these are never well defined. and may be quite lacking. The dorsal furrows are shallow and indefinite, even when the rhachis is raised. They continue to the margin to define a post-rhachial piece which may have essentially parallel sides, but usually expands backwards. This piece may be marked by an obscure depression distally, but this never amounts to a real bifurcation.

The pleural lobes are rounded or flat on top, usually falling to a more or less concave border, although the latter may be lacking. There are six pairs of pleural ribs, each gently convex, separated by rather wide, shallow furrows. The first and second furrows usually meet at, or before joining, the dorsal furrow. The first furrow is usually angularly bent at about mid-length, the others usually straight. For about half its width the first rib is bent down slightly in front to form an articulating facet.

Reed (1928, p. 57) has revived Beyrich's suggestion that the "ribs" of the pygidial pleura represent half ribs, i.e., that each second furrow is in reality a furrow along the middle of a rib, and not intercostal. In support of this concept Reed figured a specimen of *E. laticauda* in which the alternate furrows were shorter than the rest. No such alternation is seen in the specimens I have studied, in which all the furrows continue to the margin. However, this concept gains support from the recent description by Shrock & Twenhofel (1939, p. 264) of *Goldius newfoundlandensis*, a Silurian form which has only four pairs of lateral ribs but is otherwise similar to the Anticosti Silurian species *G. insularis* (Billings) (see Twenhofel 1928, p. 327), which has eight pairs of ribs. This similarity is understandable if we consider that *G. newfoundlandensis* is a *G. insularis* in which the pleural furrows have been suppressed, leaving only the intercostal furrows to define the "ribs."

The terrace lines are usually prominent and numerous, in general transverse across the anterior part of the rhachis, further back becoming convex forward. On the ribs they are convex proximad, usually interrupted in the furrows, continuing across the dorsal furrows, but sometimes with lessened prominence.

The doublure is very long, extending forward to the end of the rhachis. The complete anterior outline has not been seen in any specimen, but it seems to be simple. The doublure is marked by radial furrows corresponding in position to those of the dorsal surface, i.e., each rib is doubly convex in cross section, and the test is constricted both above and below at the furrows. The terrace lines are less numerous and more regular on the doublure than on the surface, but are very strong. They are rather regularly concave forward in the middle, and laterally run more or less parallel to the margin.

SPECIFIC DESCRIPTIONS

EOBRONTEUS BENORATUS Sinclair, n. sp.

Plate 14, figures 3, 5

Known only from cranidia and fragmentary pygidia.

The cranidium is small, very broadly rounded in front. The glabella has almost parallel sides behind, and expands moderately in front; it is sharply raised above the neck furrow behind, is almost flat on top, and falls to the anterior border in a gently convex curve. The lateral glabellar furrows are represented by barely perceptible transversely ovate smooth spots on the test; the first pair are well forward, opposite the cheek furrows, the second are at the level of farthest inbending of the facial sutures, the third are close to the second and opposite the anterior edge of the palpebral lobe. The dorsal furrows are well marked, and are deepest behind; they run obliquely in across the neck ring, then bound the glabella in a rather regular concave curve opening in front into the wide anterior border. The neck furrow is well marked, a little arched forward in the middle, rather shallow mesially but deepening laterally to form a pair of strikingly deep dimples, and dying out before reaching the dorsal furrows. The neck ring is convex, moderately long, with an almost transverse posterior margin. The palpebral lobes are well out from the glabella (about the width of the glabella removed) and are of moderate size, and subcircular. The paraglabellar lobes are small, subcircular, opposite the middle and hinder part of the

palpebral lobes; they are a little more than half as long as the latter, and are bounded by a feeble narrow furrow. The glabella is faintly constricted by a pair of obscure indentations just opposite the paraglabellar lobes.

The fixed cheeks are convex, higher than the glabella, and fall sharply in front and behind. They are crossed by more or less prominent furrows. The strongest, the cheek furrows, leave the dorsal furrow at the level of the first lateral glabellar furrow and run parallel to the anterior margin. Fainter furrows run from the level of the second glabellar furrows to the front of the palpebral lobe, but die out before reaching the latter. Another pair of furrows parallel these, leaving the dorsal furrows about halfway between them and the cheek furrows. Finally from the paraglabellar lobes a pair of furrows run obliquely back, stronger than the previous two pairs, but weaker than the cheek furrows.

The cranidium has a flat border which is narrower in front of the glabella but widens at and outside the dorsal furrows. The facial sutures cut the anterior margin almost at a right angle, run directly back for a short distance, then bend in in a gentle curve; they then reverse sharply to form almost a circle around the palpebral lobe. The course of the posterior limb of the suture is not seen.

The surface of the cranidium is covered with terrace lines, apart from the area between the margin and the cheek furrows, which is smooth. The lines are very regularly parallel in front, on the glabella roughly parallel to the anterior margin except posteriorly, where they are concentric about the raised area; on the fixed cheek they are concentric about a point just behind the palpebral lobe. On the neck ring they appear transverse, but in reality are arranged in very broad ovals, concentric about a point in the middle of the posterior margin.

Only fragmentary pygidia are known, but they indicate a rather long pygidium, rather sharply rounded behind, and quite convex. There are the usual six pairs of lateral ribs, subequal in width. There is no concave border. The postrhachial piece has almost parallel sides. The rhachis itself is not seen.

Dimensions: cranidium 6 mm. long, 9.5 mm. wide: glabella 2.5 mm. wide behind, 6.5 mm. wide in front. Figured pygidium about 13 mm. long, 18 mm. wide (this is larger than most of the fragments indicate).

Horizon.—An unnamed limestone of Black River age.

Locality.—Aluminum Company of Canada quarry, north of Ste. Anne de Chicoutimi, Quebec.

Types.—Geological Survey, Canada. Holotype cranidium 9573, paratype cranidium 1573a, paratype pygidium 1573b.

This species is much smaller than others of the genus, and the anterior border and strongly raised cheeks are distinctive.

EOBRONTEUS SLOCOMI (Bradley)
Plate 12, figures 1–4, 7–11

Goldius lunatus (BILLINGS), Weller 1903, e.p., pl. 29, fig. 14.
G. slocomi, BRADLEY 1925, p. 57, *nom. nud.*
G. slocomi BRADLEY 1930, p. 257, pl. 29, figs. 30–32.

EXPLANATION OF PLATE 12

FIGS. *1–4, 7–11*—*Eobronteus slocomi* (Bradley). All specimens from the Kimmswick limestone at or near Glen Park, Missouri. *1, 7*, pygidia, ×1. WM 48794, 48795. *2, 9–11*, the holotype cranidium and counterpart, WM 10774; *2*, ×1, *9*, ×2, lighted strongly from above, to show the position and extent of the lateral glabellar furrows, *10* ×about 4, *11* the counterpart ×2, showing the right palpebral lobe and, on the left, the cheek furrow. *3*, almost complete specimen, the pygidium of which is typical of the larger pygidia, WM 48796. *4*, part of exfoliated cranidium, ×5, to show the reticulate ornament on the cheek, WM 48797. *8*, pygidium seen from the ventral side showing the doublure and, on the left, the underside of the dorsal test, ×3, WM 28919. (p. 48)

5—*Eobronteus lamonti* (Reed) from Reed 1935, approximately ×2¼. Craighead limestone, Scotland. (p. 54)

6—*Eobronteus craigensis* (Reed) from Reed 1904, ×1¼. Craighead limestone, Scotland. (p. 54)

12—*Eobronteus grayi* (Reed) from Reed 1904, reduced about 1/7. Craighead limestone, Scotland. (p. 54)

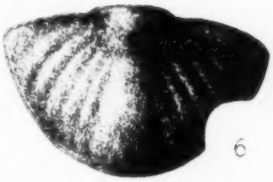
1

2

3

4

5



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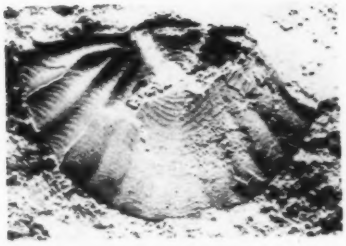

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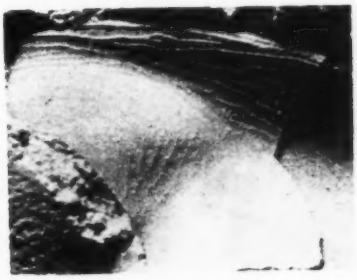

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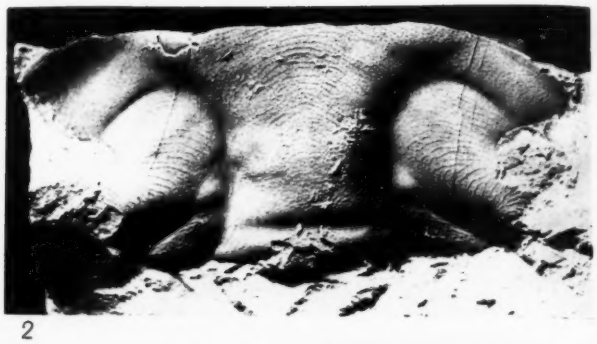
11

12

Sinclair, Ordovician Trilobite *Eobronteus*

1



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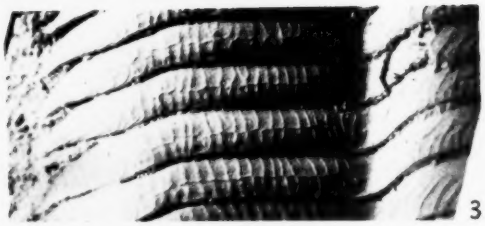

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5

6

Sinclair, Ordovician Trilobite *Eobronteus*

I have for study one fairly complete specimen, two partial cranidia (including the holotype) and ten pygidia, all from the Kimmswick limestone in the vicinity of Glen Park, Missouri. There is some variation in the shape of the pygidium and in some details of the cranidium, but other characters are uniform, and the variations are taken to be incidental to growth.

The holotype is a partial cranidium, lacking most of the fixed cheeks and pleuro-occipital areas, and exfoliated except on part of the glabella. A counterpart preserves the impression of one palpebral lobe. Bradley's original figure was apparently a photograph of the type, trimmed to the shape of cheek indicated on the counterpart: the indicated course of the sutures is quite erroneous.

The cranidium is almost flat, very wide, and the anterior margin is very broadly curved. There is a continuous anterior border, wide and concave laterally, narrowing in front of the middle of the glabella. The glabella is almost flat, raised a little behind; clavate in outline, expanding moderately in front. The lateral glabellar furrows are extremely faint, but serve to set off indistinctly a second lateral lobe. The posterior furrow is much farther back than that of *E. lunatus*. The dorsal furrows are rather deep, and continue to the front of the glabella. The fixed cheeks are well raised, but their outline is not seen. The cheek furrows are poorly preserved, but they are shallower than the dorsal furrows. The paraglabellar lobes are small and set well forward, and the oblique furrows running back from them are well marked. The palpebral lobe is small, and almost circular. The facial suture meets the anterior margin at a large angle, about 90°. (The anterior limb of the suture bounds the type on the left; the crack inked in in Bradley's figure has nothing to do with the suture.) The posterior limb of the suture is not well seen, but there are indications that the pleuro-occipital ring is as wide as in other species. The terrace lines are coarse, with no pits. They run parallel to the anterior margin on the concave border, perpendicular to the margin on the convex slope between the border and the cheek furrow. On the glabella they are roughly concentric about the raised posterior end.

A second cranidium has a peculiar reticulate pattern on the fixed cheek, but the specimen is entirely exfoliated and the significance of this appearance is not known. The cranidium of the complete specimen agrees with the holotype in so far as it is preserved, except that the anterior outline of the glabella is straighter, and the anterolateral angles are more acutely rounded.

The thorax is seen in only one specimen, and is almost completely exfoliated. A patch of shell on the right pleura of the last segment shows rather regularly longitudinal terrace lines. The overlapping portion of each rhachial ring amounts to about one-quarter its length, and is flat and depressed below the surface; the slope to the band is steep. The rhachis is quite convex, the pleurae moderately so.

The pygidial rhachis tapers rather rapidly and ends bluntly a short distance from the front. The dorsal furrows continue, flaring slightly, to the margin. The smallest pygidia (10 mm. long) are quite convex, with no border and have a rather distinct transverse furrow on the rhachis. With increase in size the pygidia become flatter, until the largest have very gently sloping, almost flat, pleura. There is also a change of outline, the larger pygidia being longer, with a more sharply rounded posterior curve. The rhachis is all well raised. Almost all the specimens are impressions of the underside of the dorsal test, so that the surface ornamentation is

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EXPLANATION OF PLATE 13

FIGS. *1, 2*—*Eobronteus curtus* Sinclair, n. sp. Basal Trenton limestone, Montmorenci County, Quebec. *1*, the holotype cranidium and partial pygidium, GSC 9572, ×1. *2*, the paratype cranidium, GSC 9572a, ×2. (p. 50)

3–6—*Eobronteus sculptus* Sinclair, n. sp. Middle Trenton, Ottawa, Canada, Royal Ontario Museum of Palaeontology No. 18734. *3, 5*, portions of the thorax, about ×5, in two kinds of lighting, to show the complex ornamentation. *4*, the same specimen, ×1, showing at the right the extent of the pygidial doublure. *6*, portion of the pygidium, ×2. (p. 53)

subdued and indistinct. However, terrace lines of the usual pattern can be distinguished. In one small specimen (figure 8) exposed from the ventral side almost the complete doublure is exposed. It is seen to be very long and essentially flat; the terrace lines are distant and strong, the furrows rather diffuse and shallow.

The complete specimen shows on the exfoliated pygidium two roughly elliptical areas, lying behind and on either side of the rhachis. The 4th and 6th pleural furrows rise approximately at the front and back of these areas, the 5th from a point on the postero-distal margin. The areas are quite distinct, although not raised. Their significance is not understood.

Dimensions: holotype cranidium, 11.5 mm. long, glabella 6.7 mm. wide behind; complete specimen about 64 mm. long, the pygidium 27.5 mm. long, 38 mm. wide.

Horizon.—Kimmswick limestone, Middle Ordovician.

Locality.—Missouri-Illinois and, according to Bradley (1925, p. 74), Independence County, Arkansas.

Types.—In Walker Museum, the University of Chicago. Holotype cranidium and impression, 10774; paratype pygidium, Bradley's figure 31 (which is the original of Weller's figure 14 of 1903), 5879; figured specimens of this paper, 48794–48797. The primary types were collected by Stuart Weller. All but one of the figured specimens of this paper are from the Clarence M. Jenni collection.

This species is similar in aspect to *E. lunatus*, but the shape of the pygidial rhachis is quite different. The head is proportionately shorter, and the glabellar furrows much less prominent. It is distinguished from *E. sculptus* by the shape of the rhachis and the flat even slope of the pygidial pleura. More specimens are needed to verify the assumption of specific homogeneity of the Kimmswick specimens.

Eobronteus curtus Sinclair, n. sp.
Plate 13, figures 1 and 2

Known only from two cranidia and an associated partial pygidium.

The cranidium is rather large, transverse, gently convex. The glabella is constricted behind the middle, and expands gently in front; it is convex from side to side, but is almost flat on top and drops to the anterior margin in a gently convex curve; it is not sharply raised behind, but rises gradually from the neck furrow. The lateral glabellar furrows are marked only by very indefinite depressions in the test and by a slight interruption of the surface ornamentation. The neck ring is well marked and rather long, longest at the sides since the neck furrow bends slightly forward at its ends, while the posterior margin is transverse. The neck furrow is rather wide, shallow but well marked; it does not quite reach the dorsal furrows.

The dorsal furrows are strong and shallow, bending in sharply across the neck ring and for a short distance in front of it, then curving rather regularly and forming with the cheek furrow a segment of an ellipse around the palpebral part of the cheek. A continuation of the dorsal furrow to the anterior margin is present but much less defined. There is a wide flat border in front of the cheeks, which narrows within the dorsal furrows and dies out about one-third the distance across the anterior part of the glabella. The fixed cheeks are fairly convex, rising from the cheek furrow in front, and falling rather sharply behind. They are crossed by two rather ill-defined linear depressions which run from the vicinity of the junction of the dorsal and cheek furrows toward the palpebral lobe, and set off a low subangulate ridge between them. A prominent depression runs obliquely out from the paraglabellar lobe along the posterior limb of the cheek. The latter is short, very wide, and acute. The palpebral lobe is comparatively small, projecting, situated rather well back and removed from the dorsal furrows about the width of the glabella at that level. The paraglabellar lobes are small, about at the level of the palpebral lobes; they are undefined except by lack of ornamentation. The facial suture cuts the anterior margin almost at a right angle, runs in straight across the border, then curves broadly to the cheek furrow; behind this furrow it reverses curvature to form almost a semicircle to the palpebral lobe; the posterior branch bends in behind the palpebral lobe in a sharp subcircular curve and then runs out almost in a

straight line to cut the posterior margin at a very small angle. The pleuro-occipital furrow is represented by a very vague depression which dies out a short distance from the dorsal furrow. The posterior margin of the head is rather steep.

The surface is marked by prominent terrace lines and large punctae, except for the paraglabellar lobes, which are smooth, and the area between the border and the cheek furrows. where there are punctae only. The lines on the border and the anterior part of the glabella are parallel to the anterior margin; the crest of the glabella is punctate but seems to be without lines; the flanks of the glabella however have lines running obliquely down and back into the dorsal furrows. The terrace lines on the cheeks behind the cheek furrows are very strong, and roughly concentric about the palpebral lobes: on the posterior limb of the cheeks the lines are irregular, but run roughly in and back.

The pygidium is poorly exposed, but seems to be somewhat similar to that of *E. reedi*, but much larger.

Dimensions: holotype cranidium, 20 mm. long, an estimated 38 mm. wide along the posterior margin and 39 mm. wide in front; the glabella is 11 mm. wide at the narrowest, 22 mm. wide in front; the neck ring is 14 mm. wide.

Horizon: A limestone of basal Trenton age.

Locality. Rivière Sault à la Puce, County Montmorenci, Quebec. Specifically, the lowest Trenton bed at the downstream end of the outlier about one-quarter mile above the falls which give the stream its name.

Types.—Geological Survey, Canada. Holotype 9572, paratype (a partial cranidium) 9572a.

EOBRONTEUS REEDI Sinclair, n. sp.
Plate 14, figures 7, 9, 10

Known only from a pygidium and a partial cranidium.

The unique cranidium is quite shattered posteriorly, but most of the essential characters can be made out. It is roughly semicircular in outline. with the corners truncated. The convexity is moderate, except at the front, where it bends down sharply. There is no border. The glabella is wide, almost flat longitudinally, gently bent down in front, evenly and gently convex from side to side. No lateral glabellar furrows are seen, possibly due to imperfect preservation. The dorsal furrows are wide, shallow and rounded on the bottom; they form a rather regular arc, convex inward, from the posterior margin to a point about one-quarter the length of the head from the front. From here (where the cheek furrow leaves) the dorsal furrow continues forward as a shallower indistinct depression to meet an intramarginal furrow. The latter is as pronounced as the main dorsal furrow, and parallels the cheek furrow; it extends inward slightly past the end of the dorsal furrow, but does not continue around the front of the glabella. The cheek furrow is as strong as the dorsal furrow, and bends back from the latter in a subcircular arc. The neck ring is rather wide, and flat. The neck furrow is very obscure, marked mainly by an interruption of the terrace lines. The facial suture is not seen, except in small stretches; the anterior segment is straight and cuts the margin at very little more than a right angle. No paraglabellar lobes are seen, again possibly due to type of preservation.

The surface of the cranidium is marked by rather coarse terrace lines, which in front run parallel to the margin, on the frontal lobe of the glabella are irregularly transverse, and between the intramarginal and cheek furrows are perpendicular to the margin. The fixed cheeks and the base of the glabella are too broken to show the course of the lines clearly. The narrow spaces between the lines are marked by numerous relatively large punctae which are usually regularly aligned along the middle of the space, but in a few places near the side of the cranidium they coincide with the terrace lines, or (as on the neck ring) are irregularly distributed with reference to them.[1]

[1] This surface pattern is entirely similar to that described by Kindle (1943, p. 161, pl. 2, fig. 1) as occurring on a fragment from the Upper Ordovician of Percé. However, similar surfaces are seen in some species of *Illaenus*, and Kindle's fragment should not be assigned generically on the basis of it. The similarity does indicate that the fragment is that of a trilobite.

The pygidium is semicircular in outline, of rather low convexity, with a gently concave slope to the margin laterally and behind. The rhachis is very obscure, short (about one-quarter the length), wholly undefined behind, and laterally marked off by obscure depressions which are rather strongly convergent; the rhachis is only slightly raised above the pleura and projects little in front. The only indication of a rhachial ring is a very obscure transverse depression just back of the anterior edge, which indents the top of the rhachis only and does not reach the dorsal furrows. The six pairs of lateral ribs are broadly rounded and separated by wide furrows, angular on the bottom which extend to the margin. The ribs are subequal in width and expand gently distally, except the second rib, which expands more rapidly since the furrows defining it meet proximally. The intercostal furrows do not arise in the dorsal furrows, but a short distance from them. The post-rhachial piece is simple and bounded by parallel furrows. The articulating facets are short and narrow, extending about one-half the distance from the anterolateral corner to the dorsal furrow. The terrace lines are very prominent and rather distant; on the rhachis they are irregular but subparallel to the anterior margin; on the ribs they are convex proximad, and are usully interrupted in the furrows which are thus smooth.

Dimensions: cranidium 16 mm. long, about 24 mm. wide in front; glabella about 10 mm. wide behind, 8 mm. wide at the narrowest. Pygidium 19 mm. long, 30 mm. wide, the rhachis 10 mm. wide in front.

Horizon.—A limestone of Middle Trenton age.

Locality.—Cap à l'Aigle, Quebec, on the beach below the Presbyterian church. Not from the breccia which is exposed there, but from undisturbed beds containing *Cryptolithus*, *Byssonychia*, etc.

Types.—The holotype cranidium and paratype pygidium are in the writer's collection, and were collected by Mrs. Sinclair.

Eobronteus lunatus (Billings)
Plate 14, figures 1, 2, 4, 6

Bronteus lunatus, Billings 1857, p. 338.
Bronteus lunatus Billings 1863, text figure 187.
Goldius lunatus, Raymond 1921, p. 32, pl. 9, fig. 8.
Eobronteus lunatus, Wilson 1948, p. 38, pl. 8, figs. 10–11.

This species has been described recently by Miss Wilson, and no repetition is needed here, but a few notes may be added.

The glabella is raised behind, almost flat on top, and slopes very gradually forward. The anterior border is wide and flat in front of the cheeks, and contracts sharply in front of the glabella but continues as a narrow ledge around the front (at least on the exfoliated head). The cheek furrow is strong, but the dorsal furrows continue to the anterior border. The paraglabellar lobes are well marked and smooth. The pleuro-occipital ring is as wide as, and entirely similar to, the first thoracic segment.

The labrum (seen in specimen 18753, Royal Ontario Museum of Palaeontology) is shield-shaped in outline, the anterior margin evenly and very broadly rounded, the sides a little concave, then gently rounded to the posterior margin. The greatest width is at the small anterolateral ears. The ventral surface which is exposed shows a pair of deep elongate pits just within the margin at the level of the lateral concavity, which continue in as depressions anterior to the macule, but do not meet in the middle. The anterior body of the labrum is gently convex

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Explanation of Plate 14

Figs. *1*, *2*, *4*, *6*—*Eobronteus lunatus* (Billings). *1*, *4*, specimen showing the displaced labrum, Royal Ontario Museum of Palaeontology 18753, ×1 and ×2. *2*, the holotype, GSC 1781, ×1. *6*, a paratype, GSC 1781a, ×1. The photographs for figures *2* and *6* were made by the Geological Survey, Canada. (p. 52)

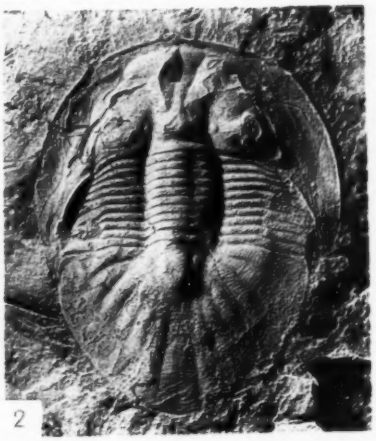
3, *5*—*Eobronteus benoratus* Sinclair, n. sp. Black River group, Ste. Anne de Chicoutimi, Quebec. *3*, holotype cranidium, GSC 9573, ×4. *5*, partial pygidium GSC 9573b, ×1. (p. 47)

7, *9*, *10*—*Eobronteus reedi* Sinclair, n. sp. Middle Trenton, Cap á l'Aigle, Quebec. *7*, paratype pygidium, ×1. *9*, *10*, holotype cranidium, ×5 (approx.) and ×2. (p. 57)

8—*Eobronteus insularis* (Eichwald), from Schmidt, ×3/5. Lower Lyckholm, Esthonia. (p. 55)

11—*Eobronteus hibernicus* (Portlock), from Portlock, approximately ×1. Caradocian, Kildare, Ireland. (p. 53)

1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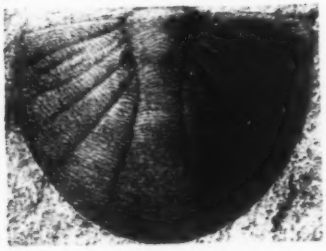
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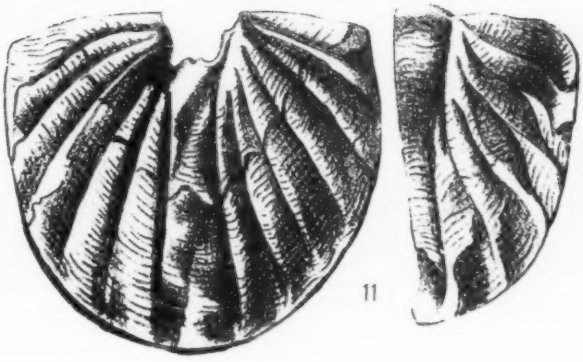
11

Sinclair, Ordovician Trilobite *Eobronteus*

and continues to the anterior margin; posteriorly it falls off gradually to a wide concave border above which the lateral and posterior margins are raised in a rim. The rather prominent maculae are situated about two-thirds the length from the front. The surface is not well preserved, but shows strong lirae inside and concentric with the posterior margin. This labrum is shorter than that described for *E. laticauda*, the anterior angles are sharp, the posterolateral outline is more even, and the flat margin in front of the body is lacking. It is about 5.5 mm. long, and 6 mm. wide.

The pygidium is almost flat.

Horizon.—Cystid beds of the Middle Trenton.

Locality.—Ottawa, Canada. Billings' specimens apparently came from the Ottawa side of the Ottawa River, and the Royal Ontario Museum specimen from the same beds at Hull, Quebec, just across the river.

Types.—Holotype (selected by Wilson 1948) Geological Survey, Canada, 1781; paratypes GSC 1781a, b, c; figured specimen of this paper, Royal Ontario Museum of Palaeontology 18753.

EOBRONTEUS SCULPTUS Sinclair, n. sp.
Plate 13, figures 3–6

Known from thorax and pygidia only.

The pygidium is elongate, the posterior outline considerably less than a semicircle. It is very gently convex. The pleurae are almost flat on top for about half their width, then slope in a concave curve to the margin. The rhachis is prominent, well raised and rather sharply defined; it is obscurely truncated behind; an obscure transverse depression sets off a very indefinite anterior ring. The dorsal furrows are very indefinitely marked. The pleural ribs are very gently convex, and are essentially straight, except the anterior rib which is limited behind by a furrow which runs out and then abruptly changes direction. The post-rhachial piece expands gently backward and is unfurrowed, although its duplicate nature is indicated by the terrace lines. The terrace lines on the pleurae are strong and distant, in general convex proximad, but those on the first rib are similar to those of the thoracic segments. The doublure is very wide, extending to the end of the rhachis, and has grooves corresponding to those of the dorsal test; it is marked with distant terrace lines which continue across the pleural furrows (those of the dorsal surface do not do so).

The thoracic rhachis is convex; the pleurae are flat for more than half their width, then bend down gently. Nine segments are seen at least in part. The sides of the pleurae are parallel almost to the tip, which is a sharp point directed a little backward. The terrace lines on the rhachis are roughly concentric about a point one segment behind the middle of the posterior margin. Those on the pleurae are difficult to describe, but can be studied from the illustrations. In general an irregular line runs along the middle of the pleura, extending to the tip and becoming more even distally; from this line short cross lines run from each side proximally, but distally they become fewer and more oblique. The doublure (distally) has distant terrace lines which are convex proximad.

Dimensions: Pygidium 29.5 mm. long (plus an undetermined small length buried at the anterior end), about 41 mm. wide; rhachis 12 mm. wide.

Horizon.—Trenton limestone. The horizon and locality are not noted in detail, but I think it probable that the specimen came from the cystid beds of the Middle Trenton although there are some beds in the Lower Trenton Hull formation of rather similar aspect.

Locality.—Ottawa, Canada.

Type.—Royal Ontario Museum of Palaeontology, Toronto, 18734.

EOBRONTEUS HIBERNICUS (Portlock)

Brontes Hibernicus, PORTLOCK 1843, p. 270, pl. 5 fig. 8.

Portlock's original description is very inadequate, amounting in fact to a statement that the pygidium is 1.62 inches long, nearly 2 inches wide. His figures show an elongate pygidium with rather broadly rounded posterior margin and sides straight for about half their length. The rhachis is not preserved.

Although the species needs restudy, there is little doubt of its distinctness.

Horizon.—Caradocian.

Locality.—Kildare, Ireland.

EOBRONTEUS GRAYI (Reed)
Plate 12, figure 12

Bronteus sp. a, NICHOLSON and ETHERIDGE 1879, p. 165, pl. 12, fig. 6.
Bronteus grayi, REED 1904, p. 90, pl. 12, fig. 14.—REED 1935, p. 360, loc. ref.
Scutellum (*Eobronteus*) *grayi*, REED 1931, p. 13, gen. ref.

This species is known from pygidia only. Reed's original description follows:

Pygidium parabolic, very slightly convex. Axis cylindrical, convex, broad and short, being about one-third the width of the pygidium and extending for about half its length; extremity rounded. Two well marked broad rings on anterior end of axis, the second ring defined behind by a furrow, which is apparently obsolete in the middle. Axial furrows strong in front but weak posteriorly and faintly encircling extremity of axis. Lateral lobes composed of seven pairs of flattened pleurae; the first six well defined and separated by strong interpleural furrows; the seventh pair fused in middle line behind axis, the interpleural furrow extending only a short distance behind it. Sixth pair of interpleural furrows directly continuous with axial furrows, slightly divergent towards posterior margin. All the interpleural furrows die out some distance from the margin of the pygidium.

First pleura imperfectly preserved. Second pleura of nearly uniform and constant width, bending back rather suddenly at about half its length. Third pleura very narrow at base, but expanding steadily towards extremity. Fourth pleura of greater and uniform width, curving regularly backward, starting at an angle of about 30° to axial line. Fifth pleura of same width at base as fourth, but expanding towards extremity. Sixth pleura of about same dimensions as the fifth, but running nearly straight backwards. Doublure of pygidium broad and concentrically striated.

Dimensions.—Length, 50 mm. (approx.), width, 55; length of axis, 24, width of same 22.

Horizon.—Craighead limestone, Upper Ordovician.

Locality.—Craighead, Girvan district, Scotland.

Holotype.—British Museum (Natural History) 22672.

EOBRONTEUS CRAIGENSIS (Reed)
Plate 12, figure 6

Bronteus craigensis, REED, 1904, p. 89, pl. 12, fig. 12, 13.—REED, 1935, p. 360, loc. ref.
Scutellum (*Eobronteus*) *craigensis*, REED, 1931, p. 13, gen. ref.

This species is known only from pygidia. Reed's original description follows:

Pygidium semi-circular, very slightly convex. Axis short, conical, feebly convex, broader than long, about one-third the length of the pygidium and less than one fourth its width; consisting of one or two faintly-marked rings at the front end and of a triangular piece behind. Axial furrows very faint, converging at about 80°, but obsolete at posterior end of axis. Lateral lobes composed of six pairs of simple radiating, slightly raised pleurae, curving gently backwards, and separated by distinct but shallow interpleural furrows, dying out near margin. Sixth pair of pleurae very indistinctly defined. Broad post-axial piece, apparently composed of the completely fused seventh pair of pleurae, but without any trace of an interpleural furrow.

Dimensions.—Length 18.0 mm., width 29; length of axis 6.5, width of same, 7.

Horizon.—Craighead limestone, Upper Ordovician.

Locality.—Craighead, Girvan district, Scotland.

Syntypes.—British Museum (Natural History), 22668 (fig. 12), 22669 (fig. 13) and 22670 (unfigured).

EOBRONTEUS LAMONTI Reed
Plate 12, figure 5

Scutellum (*Eobronteus*) *lamonti*, REED 1935a, p. 25, pl. 1, fig. 1.

This species is known from a cranidium only. Reed's original description follows:

Head-shield transversely semicircular, very slightly convex. Glabella clavate, widest near base, expanding in front to more than twice its basal width, without lateral furrows or pits, defined by well-marked axial furrows concave outwards and diverging widely anteriorly, and less so posteriorly on each side of the meso-occipital ring; anterior end of glabella indistinctly defined, with small rounded slightly overhanging lateral angles. Meso-occipital ring broad, with small median tubercle; meso-occipital furrow strong, horizontal. Fixed cheeks with wide lateral expansion to anterior wing, more than half as wide as anterior end of glabella, having a narrow rounded anterior border marked off by a weak marginal furrow and followed behind by a wider low gently convex concentric band meeting the lateral angles of the glabella; rest of fixed cheek rather swollen, with large prominent rounded eye-lobe situated far back at a little more than its own width from posterior edge of head-shield; posterior wing of fixed cheek very narrow, projecting laterally, acutely pointed; pleuro-occipital ring narrowing laterally, well marked off by furrow from cheek. Facial suture with anterior branch bending out sharply at acute angle in front of eye in sigmoidal curve to cut anterior margin of head-shield far out; posterior branch running outwards nearly straight to cut posterior margin of head-shield at very acute angle at about 1½ times the basal width of glabella.

Dimensions.—Length, 8 mm., width between anterior ends of sutures, estimated at 13 mm.

Horizon.—Craighead limestone, Upper Ordovician.

Locality.—Craighead, Girvan district, Scotland.

Holotype.—Collection of Archie Lamont, Edinburgh, Scotland.

EOBRONTEUS INSULARIS (Eichwald)
Plate 14, figure 8

Bronteus insularis EICHWALD 1857, p. 336.—EICHWALD 1861, p. 1492, pl. 53, fig. 9.
B. laticauda (Wahlenburg), NIESKOWSKI 1859, p. 370.—SCHMIDT 1894 e.p., p. 34, pl. 3, fig. 10, ?9.
Goldius laticaudus (Wahlenburg), TWENHOFEL 1916, p. 298 seq. loc. ref.

Eichwald's species has been suppressed by Schmidt and by Warburg, who placed it in synonymy with *E. laticauda.* However, the pygidium is more elongate than in the Swedish species and the post-rhachial piece flares more. The position and shape of the ribs seems to be peculiar, but the asymmetry of Schmidt's figure "drawn from a photograph of Eichwald's type" makes it suspect as to details. The general shape would seem to merit distinction. I have seen no specimens of the species.

Horizon.—Lower Lyckholm, Upper Ordovician.

Locality.—Worms Island, Esthonia.

If the cranidium figured by Schmidt from Dago Island (fig. 9) belongs to this species it is sharply set off from *E. laticauda* by its short broad glabellar neck and the strength of the dorsal furrows in front of the cheek furrow, as well as by the pronounced anterior border.

EOBRONTEUS LATICAUDA (Wahlenburg)

Entomostracites laticauda, WAHLENBURG 1818, p. 28 e.p., pl. 2, fig. 8
Bronteus laticauda, WARBURG 1925, p. 141, pl. 3, figs. 3–15.

I have nothing to add to Miss Warburg's exhaustive description. Wahlenburg's original figure is not accurate, but is similar enough to Miss Warburg's figure 12 to suggest that they represent the same specimen.

The differences in pygidial rhachis and in glabellar proportions seen in Warburg's figures of specimens from Kallholn and from Osmundsberg suggested to me a composite species. However, Miss Warburg tells me that she does not consider the forms separable. Since the species is a common one in the Boda there is opportunity for asessment of variation, and it may be that I am dividing the American forms too finely.

Horizon.—Boda limestone, basal Silurian.

Locality.—Typically Osmundsberg, Dalarne, Sweden; other localities in Sweden and Norway.

Types.—Upsala University collections.

EOBRONTEUS sp. ?

Illaenus sp. ind. I, TROEDSSON 1929, p. 40, pl. 14, fig. 5.

This specimen from the Cape Calhoun beds at Cape Calhoun, North Greenland, seems from Troedsson's description and figure to be at least possibly an eobronteid. It is mentioned here since the genus has not been reported from the Arctic Ordovician, although *Scutellum* is present there in the Silurian.

EOBRONTEUS?? RICHTERI (Sun)

Bronteus richteri, SUN 1931, p. 20, pl. 3, figs. 2, ?3.

This species, from the Middle Ordovician Neichia group of Kweichau, China, was founded on an imperfect pygidium. Neither Sun's figure nor description is sufficient to warrant certain reference to *Eobronteus*, nor to refer the species elsewhere with any confidence. The circumscribed rhachis and pustulose surface argue against it being an eobronteid.

The associated partial cranidium is not described, but the figure shows a regularly curved meso-occipital furrow, a glabella expanding forward from the neck ring, and the palpebral lobe well forward and close to the glabella. None of these features are characteristic of the genus.

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CONODONTS FROM THE LOWER MISSISSIPPIAN PROSPECT HILL SANDSTONE OF IOWA

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ABSTRACT—Recently an abundant conodont fauna was discovered in the Prospect Hill sandstone at three localities (including the type section) in southeastern Iowa. A detailed study of this assemblage shows that the great majority of the specimens are referable to the genus *Polygnathus*. However, *Bryantodus*, *Hindeodella*, *Pinocognathus?*, *Pseudopolygnathus*, *Siphonodella*, and *Spathognathodus* are also represented. Sixteen new species are described and illustrated. In generic as well as specific composition, this fauna is very similar to that known from the Hannibal formation of Missouri, and it is also close to the assemblage from the Bushberg sandstone of the same State.

During the progress of investigations for the Iowa Geological Survey, Dr. M. A. Stainbrook noted the presence of an extensive conodont fauna in the Prospect Hill sandstone of southeastern Iowa. He brought the occurrence to our attention, and subsequently a large number of conodonts were assembled from that stratigraphic unit at three localities. These conodonts are the basis for the present report.

STRATIGRAPHIC CONSIDERATIONS

The term Prospect Hill was introduced into Iowa stratigraphic nomenclature by Moore in 1928 during a study of the Kinderhook and Osage beds of the upper Mississippi Valley. The type section is at Prospect Hill, located in the southeastern part of the city of Burlington. This outcrop at Prospect Hill has been studied a great deal, for it presents an unusually well exposed stratigraphic section for a region in general heavily covered by glacial drift. Van Tuyl (1925, p. 53) stated that the most representative and nearly complete section of the Kinderhook "in the whole of southeastern Iowa is in the Mississippi river bluff at Burlington. The Prospect Hill exposure is especially favorable for field study." Owen (1852, pp. 90–92) was the first to call attention to this section. In 1858 Hall discussed the outcrop, as did White (1860 and 1870) and Keyes (1895). Weller (1900, pp. 59–79) listed in detail the fauna of the beds exposed at Prospect Hill. Van Tuyl enlarged the description of these Kinderhook strata, and added to the faunal list given by Weller.

The section at Prospect Hill (Van Tuyl, 1925, p. 54) includes at its top some 5 feet of dolomitic limestone, which in turn are underlain by 3 feet of oolitic limestone, 6 feet of fine-grained sandstone, 11 feet of limestone, 22 feet of massive fine-grained sandstone, and at the bottom of the section (as far toward the river level as can be seen) about 19 feet of bluish-grey shale. Moore (1928, pp. 22–24) stated that the three-foot oolitic limestone bed near the top of the exposure is the Chouteau, and he proposed the name Prospect Hill for the underlying six-foot bed of fine-grained sandstone (a siltstone at some localities). He regarded this unit as the uppermost member of the Hannibal formation. In descending order, the underlying stratigraphic units are, according to Moore, the "McKerney" [McCraney, *fide* Weller and Sutton, 1940, p. 784] member (11 feet of limestone), the English River sandstone member (22 feet of massive sandstone), and the Maple Mill shale member (basal 19 feet of exposed section).

In discussing "Bed 5, here designated the Prospect Hill sandstone" Moore (1928, pp. 23–24) stated that it "contains a large Chouteau element in its fauna but it is lithologically and faunally more closely allied to the Hannibal formation at Burlington." However, Laudon (1929, pp. 376, 379) proposed the name "Hampton" formation for "beds 3, 4, 5, and 6 of the Kinderhook section at Burlington" and stated that

the "Hampton formation carries an abundant fauna in its base that may be definitely correlated with the upper portion of the Chouteau limestone of Missouri." In 1935 (correlation chart, p. 245) Moore followed Laudon in utilizing the term Hampton for beds in southeastern Iowa lying above the English River sandstone and considered to be equivalent to the Chouteau and Sedalia formations of Missouri and Illinois. An unconformity was postulated between the English River and the overlying strata. Still later, however, Weller and Sutton (1940, pp. 784–785) tentatively retained Moore's classification of 1928 and recognized the Prospect Hill member in the type section at Burlington; in addition, they stated that this Hannibal member appears in slightly greater thickness at Fall Creek, Illinois. In general, lithologic evidence does not yield an apparent solution to this problem.

AGE OF THE CONODONTS

Faunal evidence differentiating Bushberg, Hannibal and Chouteau strata likewise seems to have been none too diagnostic. Branson and Mehl (1938, pp. 128–137) concluded that the Bushberg and Hannibal formations are essentially contemporaneous and stated that with "the exception of the introduction of *Gnathodus*, the Chouteau conodonts could all be direct descendants from the Bushberg-Hannibal faunas. Some of the differences probably resulted from different types of environment." Recently, Branson (1944, p. 189) in discussing the Hannibal formation, commented that the "Bushberg was in the main contemporaneous [with the Hannibal] and part of the Hannibal seems to have been deposited at the same time as part of the Chouteau."

The evidence from the conodonts under consideration also is not entirely conclusive, and both Bushberg-Hannibal and Chouteau elements can be recognized in our present assemblage. However, in general, the fauna appears to be more nearly that of the Bushberg-Hannibal zone. In addition, no representatives of the genus *Gnathodus* appear in our collections. As has been pointed out by Branson and Mehl, *Gnathodus* appears in the Chouteau but not in the Bushberg or Hannibal. Although the exact stratigraphic level of the introduction of *Gnathodus* into the Mississippian faunas is uncertain, that generic form, with a very broadly excavated aboral platform surface, does not appear to be closely related to conodonts of the Upper Devonian. Rather, it is much more nearly allied to *Idiognathodus* and *Streptognathodus*, which are so characteristically and well developed in the Pennsylvanian.

Although in general the apparent lack of a genus is of doubtful significance, it seems to us that the absence of *Gnathodus* in the present collections may be taken as a further indication of a pre-Chouteau age for the assemblage.

The conodont fauna under consideration is believed to be essentially contemporaneous with that of the Hannibal formation of Missouri, and at least in part equivalent to the fauna known from the Bushberg sandstone. On the basis of the conodonts, Moore's 1928 identification of bed 5 of the Prospect Hill section as the top portion of the Hannibal appears to be correct. Accordingly, we are retaining his name "Prospect Hill" for this member.

COLLECTING LOCALITIES

Although varying in thickness, portions of the sequence of beds exposed in the section at Prospect Hill also appear at a number of other localities in the southeastern part of the State. Udden (1901, pp. 72–73 described an exposure of Lower Mississippian rocks in southeastern Louisa County that includes approximately five feet of calcareous sandstone (Moore's Prospect Hill) directly underlying the oolitic limestone of the Chouteau. Bain (1896, p. 127) described a similar sequence of rocks along the English River in the northwestern part of Washington County, and this section was later restudied by Van Tuyl (1925, pp. 71–72) who gave a more detailed description of the stratigraphic sequence. In Van Tuyl's description, the oolitic limestone of Moore's "Chouteau" is plainly indicated and is directly underlain (as at Prospect Hill) by a thin bed of fine-grained sandstone which is almost certainly Moore's Prospect Hill member of the Hannibal formation.

The collections of conodonts under consideration were assembled from the three previously described outcrops. The detailed localities are as follows:

(1) The type section of the Prospect Hill sandstone at Prospect Hill, southeastern part of Burlington, Des Moines County, Iowa.
(2) Lower portion of Prospect Hill sandstone exposed in the east bank of a small creek in the N½ SE¼ Sec. 34, T. 73 N., R. 2 W., Louisa County, Iowa.
(3) Lower portion of Prospect Hill sandstone cropping out along the south side of the English River in the SW¼ SE½ Sec. 8, T. 77 N., R. 8 W. (approximately 200 yards east of bridge), Washington County, Iowa.

It should perhaps be noted that at the last locality (3) the conodonts are associated with a large number of undoubted fish teeth and plates.

Conodonts were found to be moderately abundant in the type section of the Prospect Hill member and in the exposure along the English River. The majority of the specimens, however, came from the outcrop in Louisa County. At all these places, however, the assemblages are strikingly similar in both generic and specific composition and there is little doubt but that we are dealing with the same fauna at the three localities.

English River conodonts

In connection with the present report, it should perhaps be noted that E. R. Branson has studied conodonts secured from the English River sandstone in Iowa. He states (1934, p. 302) that the "conodont fauna of the English River sandstone of Iowa, although lacking in many characteristic species, is distinctly that of the Hannibal." It may be that these conodonts were secured from the Prospect Hill member of the Hannibal formation as now understood. However, they may well have come from the English River proper and since that member cannot be readily distinguished physically (lithologically or otherwise) from the comparatively thin, overlying McCraney and Prospect Hill members at some localities, there is no reason to assume that these stratigraphic units should yield very different faunas. We believe these strata do not differ greatly in age.

Summary and conclusions

The type locality and two other outcrops of the Prospect Hill sandstone in southeastern Iowa have yielded a large number of conodonts. The majority of the specimens belong in *Polygnathus*, but six other genera are also represented. Although some Chouteau elements are present among these conodonts, the containing beds are considered to be essentially contemporaneous with the Hannibal formation of Missouri, and in part at least, equivalent to the Bushberg sandstone of the same State.

Acknowledgments

We are indebted to Dr. M. A. Stainbrook for calling our attention to the presence of the conodont fauna which is the basis of this paper. Also, we express our appreciation to Professor A. K. Miller of The State University of Iowa for advice and assistance throughout the preparation of this report. The generous cooperation of the Iowa Geological Survey and particularly that of Dr. H. Garland Hershey, State Geologist has facilitated our work. Dr. W. H. Hass of the United States National Museum has kindly advised us on several nomenclatural points. The illustrations are photographs which were retouched by Mr. Howard Webster of Iowa City, and all are ×25. The types and figured specimens have been placed in the repository of the Geology Department at The State University of Iowa.

Systematic paleontology

Bryantodus rudis E. R. Branson

Plate 15, figure 4

Bryantodus rudis E. R. Branson, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, pp. 325–326, pl. 28, fig. 29.
Bryantodus rudis E. B. Branson *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 133.

Cusp and bar stout, entire specimen gently bowed and arched. Denticles rounded in cross section and essentially discrete to the place of junction with the bar. Although somewhat incomplete posteriorly, this specimen is closely similar to the holotype of the species.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa. Originally described from the Hannibal formation of Missouri.

Figured Specimen.—State Univ. Iowa, 4157.

HINDEODELLA sp.
Plate 15, figure 6

Bar rounded on oral side, slightly sharpened aborally. Cusp and major denticles stout and rounded in cross section. Denticles more or less recumbent, particularly toward the posterior portion of the specimen. Small or medium sized denticles occur sporadically between adjacent large denticles, but no regular intercalated series of denticles is apparent. Entire specimen moderately bowed but not appreciably arched.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa.

Figured Specimen.—State Univ. Iowa, 4111.

PINOCOGNATHUS? DEFLECTA Youngquist and Patterson, n. sp.
Plate 15, figure 5

Blade short, high, thick, composed of some twenty-four denticles which are stout and closely fused nearly to their apices. All of the denticles are inclined in a direction that is assumed to be posterior. Blade laterally deflected inward in posterior portion. Maximum height of blade attained slightly posterior of midlength. At this place the cusp is very closely approximated in size by an adjacent denticle. Entire specimen gently bowed and arched. Escutcheon small. Near the aboral margin of the holotype, the blade is thickened on the inner (unfigured) side but this thickening in no way becomes platform-like or shelf-like in its lateral extension.

Branson and Mehl (1934, p. 269) pointed out that *Pinocognathus* "stands close to" *Spathognathodus*. It should also be mentioned that some forms of the very long ranging and rather broadly interpreted genus *Ozarkodina* are close to some specimens referred to *Pinocognathus*. In addition, *Prioniodella* and *Bryantodus* both of Ulrich and Bassler (1926, pp. 18, 21) and some forms of *Solenodella* are at least superficially similar to *Pinocognathus*. It is doubtful if all of these generic names, as now defined, should continue to be recognized.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa.

Holotype.—State Univ. Iowa, 4112.

POLYGNATHUS ADUNCA Youngquist and Patterson, n. sp.
Plate 16, figures 18, 19

Plate broadly rounded on outer side, fairly straight along posterior margin of inner side to approximately midlength and then sharply deflected inward. Inner margin of anterior half of plate comparable in outline to outer margin. Oral lateral zones of

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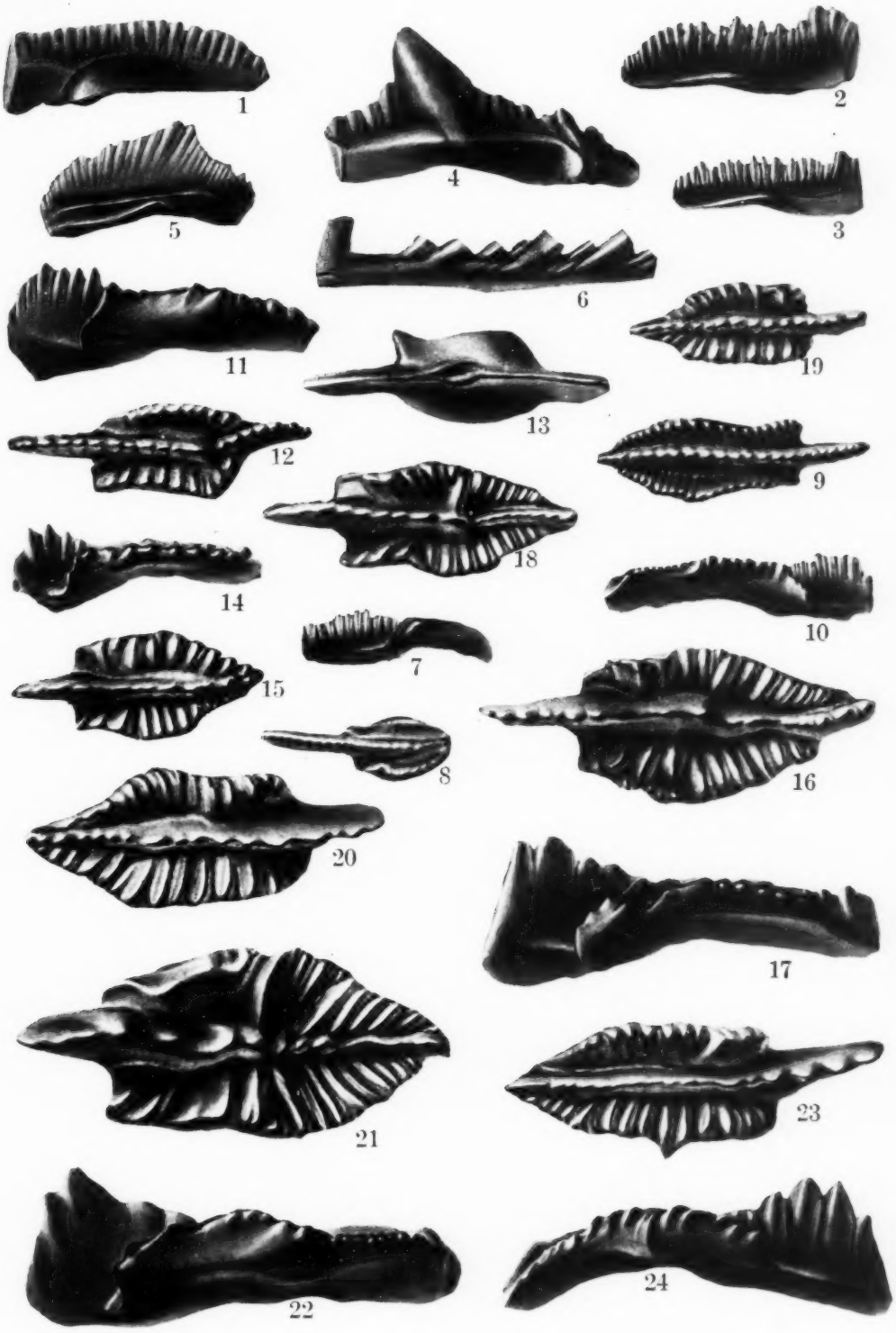
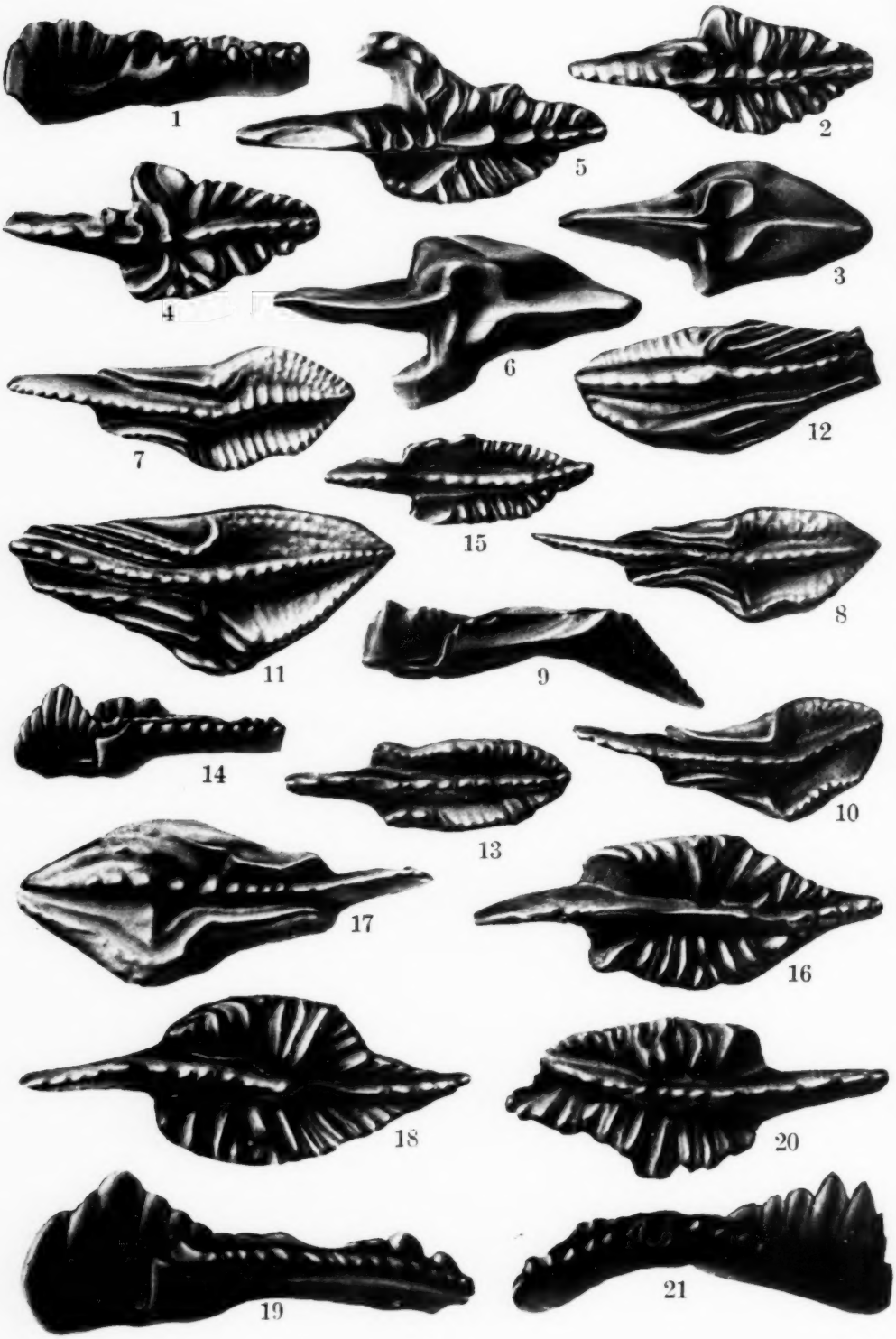
EXPLANATION OF PLATE 15

All specimens illustrated are from the Prospect Hill sandstone at the following locations: type section at Burlington, Iowa, figs. *2, 7–10, 19, 21, 22;* southeastern Louisa County, Iowa, figs. *1, 4, 18;* northwestern Washington County, Iowa. figs. *3, 5, 6, 11–17, 20, 23, 24*. All figures are ×25.

FIGS. *1*—*Spathognathodus sulciferus* (Branson and Mehl). (p. 72)
2—*Spathognathodus crassidentatus* (Branson and Mehl). (p. 71)
3—*Spathognathodus aciedentatus* (E. R. Branson). (p. 71)
4—*Bryantodus rudis* E. R. Branson. (p. 59)
5—*Pinocognathus? deflecta* Youngquist and Patterson, n. sp. Outer lateral view of the holotype. (p. 60)
6—*Hindeodella* sp. (p. 60)
7, 8—*Polygnathus communis* Branson and Mehl. (p. 62)
9, 10—*Polygnathus sagittaria* Youngquist and Patterson, n. sp. Oral and lateral views of the holotype. See also pl. 16, fig. 13. (p. 66)
11–13—*Polygnathus cunulae* Youngquist and Patterson, n. sp. Three views of the holotype. (p. 62)
14, 15—*Polygnathus symmetrica* E. R. Branson. (p. 67)
16–20—*Polygnathus longipostica* Branson and Mehl. Figures *16, 17*, represent one specimen. (p. 65)
21, 22—*Polygnathus multilirata* Youngquist and Patterson, n. sp. Oral and lateral views of the holotype. (p. 65)
23, 24—*Polygnathus biclavula* Youngquist and Patterson, n. sp. Two views of the holotype. (p. 61)



Youngquist and Patterson, Lower Mississippian Conodonts



Youngquist and Patterson, Lower Mississippian Conodonts

plate more or less transversely rugose. Medially, a sinuous carina extends the entire length of the plate. It is high anteriorly, low in midportion, and prominently nodose posteriorly. Blade subtriangular in lateral profile (see fig. 19) and composed of about seven closely fused denticles, the largest of which is located midlength in the blade. Aborally, there is a large keel both anteriorly and posteriorly. Escutcheon not well developed. The entire specimen is only gently bowed and arched.

The distinctive deflection of the inner lateral margin, the large subtriangularly shaped blade, the very gentle arching, and the large nodes posterior in the carina distinguish this species from congeneric forms.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4113.

POLYGNATHUS BICLAVULA Youngquist and Patterson, n. sp.
Plate 15, figures 23, 24

Plate long, rather lanceolate, particularly characterized by two laterally directed node-like processes which originate one on each of the aboral-lateral zones and are located slightly anterior of midlength on the plate. Marginal areas of the plate are transversely crenulated by short ridges. Carina is high anteriorly, low at midlength, and somewhat nodose posteriorly. Blade is rather stout and consists of about five denticles which are partially discrete and attain maximum height midway on the blade. Anterior-aboral portion of blade is somewhat attenuate. Aboral-lateral process on outer side of the plate extends to the oral margin and is visible from an oral view (see fig. 23), but the corresponding process on the inner side is wholly confined to the aboral zone.

The laterally directed node-like processes on the aboral-lateral zones of the plate distinguish our species from such probably related forms as *P. longipostica* Branson and Mehl. *P. biclavula*, n. sp. is perhaps closest to *P. permarginata* E. R. Branson from the Hannibal formation of Missouri. Branson states (1934, p. 312) that on his holotype of that species "a laterally directed boss on the inner side near the aboral surface occurs just in front of mid-length" on the plate. Our species has nodes on both the inner and outer sides of the plate. Determining orientation from the curvature of the blade, our holotype has the larger of its two nodes on the outer side. *P. permarginata* has a blade which "rises sharply from the lower anterior corner to the highest point and thence slopes gently to its junction with the carina." In

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EXPLANATION OF PLATE 16

All specimens illustrated are from the Prospect Hill sandstone in southeastern Louisa County, Iowa, with the exception of figures *11* and *12* which are from a similar horizon in northwestern Washington County, Iowa. All figures are ×25.

FIGS. *1–3—Pseudopolygnathus irregularis* E. R. Branson. (p. 68)
4—Pseudopolygnathus carinata Youngquist and Patterson, n. sp. Oral view of the holotype. (p. 68)
5, 6—Pseudopolygnathus aurita Youngquist and Patterson, n. sp. Oral and aboral views of the holotype. (p. 67)
7–10—Siphonodella duplicata (Branson and Mehl). Figures *7*, *10*, represent two individuals. Oral and lateral views of a single specimen are shown by figs. *8*, *9*. (p. 69)
11—Siphonodella quadruplicata (Branson and Mehl). (p. 70)
12—Siphonodella sexplicata (Branson and Mehl). (p. 70)
13—Polygnathus sagittaria Youngquist and Patterson, n. sp. Paratype. See also plate 15, figs. *9*, *10*. (p. 66)
14, 15—Polygnathus inaequilateralis Youngquist and Patterson, n. sp. Lateral and oral views of the holotype. (p. 63)
16—Polygnathus lanceolata E. R. Branson. (p. 64)
17—Siphonodella ponderosa Youngquist and Patterson, n. sp. The holotype. (p. 69)
18, 19—Polygnathus adunca Youngquist and Patterson, n. sp. Two views of the holotype. (p. 60)
20, 21—Polygnathus inopinata Youngquist and Patterson, n. sp. Oral and lateral views of the holotype. (p. 64)

contrast, the blade of our specimen is highest approximately at midlength and its oral margin is prominently denticulate. *P. permarginata* has the oral edge of the blade broken only by "several indistinct crenulations."

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa.

Holotype.—State Univ. Iowa, 4114.

POLYGNATHUS COMMUNIS Branson and Mehl
Plate 15, figures 7, 8

Polygnathus communis E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 293, pl. 24, figs. 1–4.
Polygnathus communis E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 308, pl. 25, figs. 5, 6.
Polygnathus communis E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.
Polygnathus communis E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 132, 145, pl. 33, fig. 55; pl. 34, figs. 39–41.
Polygnathus aff. *P. communis* KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.
Polygnathus communis COOPER, 1939, Jour. Paleontology, vol. 13, pp. 399, 420, pl. 39, figs. 1, 2, 9, 10, 23, 24.
Polygnathus communis HASS, 1943, Jour. Paleontology, vol. 17, p. 308.
Polygnathus communis E. B. BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 245, pl. 94, figs. 29–31.
Polygnathus communis E. B. BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, fig. 55; pl. 39, fig. 40
Polygnathus communis HASS, 1947, Jour. Paleontology, vol. 21, pp. 136, 137.
Polygnathus communis MEHL and THOMAS, 1947, Denison Univ. Bull., Jour. Sci. Labs., vol. 40, pp. 7, 15, pl. 1, fig. 37.

Plate nearly as wide as long, and relatively smooth on oral surface except for median carina. Entire specimen gently bowed and arched. Blade and plate subequal in length. Blade much compressed laterally and consists of some 10 to 12 denticles which are distally discrete.

The illustrated specimen is strikingly similar to the syntypes of this species described by Branson and Mehl from the Bushberg sandstone of Missouri. However, it does not appear to be particularly close to some of the other specimens which have been referred to *P. communis*. In view of Branson and Mehl's statement (1934), p. 293) that the plate is "nearly oval in outline" it is doubtful if all of the specimens subsequently referred to *P. communis* belong in it. For the present we are tentatively regarding only the forms included in the foregoing synonomy as conspecific. *P. communis* of Mehl and Thomas has a relatively attenuate platform for the species, as was noted by those authors (1947, p. 15).

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa. Also reported from strata of Bushberg, Hannibal, Chouteau, and Fern Glen age in Missouri; the basal Orangeville and basal Sunbury shales of Ohio; a "Bushberg-Hannibal horizon" in Oklahoma, and from a thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana.

Figured Specimen.—State Univ. Iowa, 4115.

POLYGNATHUS CUNULAE Youngquist and Patterson, n. sp.
Plate 15, figures 11–13

Most of plate broadly rounded in oral outline on inner side, flared laterally on outer side. Posterior portion of plate very attenuate and only wide enough to bear the nodose carina. Crenulations of plate confined to margins; zones between plate margins and carina smooth, depressed. Blade relatively short, rather high, composed of about eight denticles which attain maximum development in the posterior four. Aborally, a small escutcheon is developed slightly anterior of midlength of the plate. The blade is slightly keeled; the plate moderately so.

This species is distinct from all congeneric forms in this Prospect Hill assemblage and from those previously described, in that the outer plate margin is flared laterally, giving the plate a very asymmetrical appearance. Also, the posterior portion of the plate is much attenuated.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa.

Holotype.—State Univ. Iowa, 4116.

POLYGNATHUS CYMBIFORMIS Youngquist and Patterson, n. sp.
Plate 17, figures 14, 15

Plate hastate in oral outline, prominently rugose transversely. Carina on anterior half of plate large, high, grading into the blade. The carina ends abruptly near the midlength of the plate and then reappears slightly posterior of this place in much subdued and

somewhat nodose fashion. Also, on the midportion of the plate there are two prominent ridges which extend obliquely anterior from the inner and outer margins of the plate, and merge with the posterior end of the high portion of the carina. The blade is high, slopes up smoothly from its rounded anterior aboral portion to its highest point and then, in crenulate form, descends posteriorly to merge with the carina. Aborally the holotype is prominently keeled both anteriorly and posteriorly. A small escutcheon is present slightly anterior of midlength on the plate.

The high carina which ends abruptly in the midportion of the plate, and the oblique rugae extending from the margins of the plate to the posterior end of the high carina are distinctive of this form.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4117.

POLYGNATHUS HANNIBALENSIS Youngquist and Patterson, n. sp.
Plate 17, figures 16, 17

Holotype long, low, clavate in lateral profile (see fig. 16). Oral outline of plate broad, almost bilaterally symmetrical, and somewhat acuminate in its posterior third. Ornamentation consists of some 10 or 12 rather large transverse ridges which extend from the lateral margins of the plate to, or almost to, the carina. This latter structure is distinct but no more than ordinarily prominent for a specimen the size of the illustrated holotype. Blade is low, and in length is slightly less than half the length of the plate. It consists of about eight denticles which are markedly fused and serve only to slightly crenulate the oral blade margin. A very small keel is present anterior and posterior to an indistinct escutcheon which is situated slightly anterior of midlength on the aboral plate surface.

Superficially, the illustrated specimen resembles that figured by Branson and Mehl (Branson *et al.*, 1938, pl. 24, fig. 48) and designated *P. flabella*. However, in that form the transverse ridges of the plate are stated to only reach "one-third to one-half the distance" to the carina and the carina is more nodose. *P. hannibalensis* n. sp. in oral view also resembles the specimen illustrated by Cooper (1939, pl. 39, figs. 31, 32) and referred to *P. longipostica*. However, it is stated in the description of that form, that the blade is composed of a "small number of denticles in a cockscomb arrangement" (which is in agreement with the blade of typical *P. longipostica*). Presumably, therefore, our holotype is quite distinct from that form since the blade of this Prospect Hill specimen is low, and composed of eight closely fused denticles which only very slightly crenulate the oral margin of the blade. Also, the blade is not distinctively attenuate in its anterior-aboral portion (as in the types of *P. longipostica*).

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4118.

POLYGNATHUS INAEQUILATERALIS Youngquist and Patterson, n. sp.
Plate 16, figures 14, 15

Polygnathus subserrata [part] COOPER, 1939, Jour. Paleontology, vol. 13, pp. 404, 420, pl. 40, figs. 9, 10.

Anterior margins of plate flared laterally and curved orad. Inner anterior plate margin extends considerably farther orad than outer plate margin. Plate attenuate in posterior portion and terminated abruptly (see lateral view, fig. 14). Blade short but high, subtriangular in lateral outline, composed of seven denticles which attain maximum size in third, fourth and fifth ones. Nodose carina persists the length of plate, becoming somewhat spinose in posterior portion. Aborally, the plate and blade are distinctly keeled and a large, rounded, although slightly elongate escutcheon, is situated near the anterior end of the plate.

The unequal development of the anterior-lateral zones of the plate, the short, high blade and the abrupt posterior termination of the plate distinguish this species from congeneric forms. The incomplete specimen from a "Bushberg-Hannibal horizon" in Oklahoma which has been placed in synonymy appears to be very similar to our figured holotype.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa, and a "Bushberg-Hannibal horizon" in Oklahoma.

Holotype.—State Univ. Iowa, 4119.

POLYGNATHUS INOPINATA Youngquist and Patterson, n. sp.
Plate 16, figures 20, 21

Plate very asymmetrically terminated posteriorly. That is, the carina, which as a rule in representatives of *Polygnathus* extends to the posterior tip of the plate, diverges in its posterior third and terminates against the posterior-lateral margin of the plate. Carina is predominantly nodose and anteriorly merged with the blade. Six denticles constitute the blade; all but the anterior-most denticle are large and discrete adapically. The anterior-aboral portion of the blade is somewhat attenuate. The margins of the plate are prominently plicated; the outer margin in particular becomes somewhat nodose or spinose posteriorly. Aborally, the plate bears a small but distinct keel terminating at the posterior tip of the plate and therefore, in the posterior third of the plate, it does not directly underlie the carina which diverges to the inner lateral plate margin. A small elongate escutcheon is present somewhat anterior of midlength of the plate.

The figured holotype is unique in the manner in which the carina is situated. No similar specimens are known. It should be added that a careful study of this form does not indicate that it has been broken in any way; the inner plate margin is well formed and gently rounded just as is the outer margin.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4120.

POLYGNATHUS INORNATA E. R. Branson
Plate 17, figures 4, 5, 9, 13

Polygnathus inornata E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 293, pl. 24, figs. 5–7 [specific name ascribed to E. R. Branson].

Polygnathus inornata E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 309, pl. 25, figs. 8, 26.

Polygnathus inornata E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.

Polygnathus inornata E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 132, 146, pl. 33, fig. 15; pl. 34, fig. 37.

Polygnathus inornata KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.

Polygnathus inornata COOPER, 1939, Jour. Paleontology, vol. 13, pp. 400, 420, pl. 39, figs. 11, 12.

Polygnathus inornata HASS, 1943, Jour. Paleontology, vol. 17, p. 308.

Polygnathus inornata E. B. BRANSON and MEHL, and E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, figs. 51, 52; pl. 39, fig. 37.

This species has been rather broadly interpreted. Only a reasonably similar oral outline, relatively large plate, small blade, and particularly the fact that (Branson and Mehl, 1934, p. 293) "some species have one margin much higher than the other" serve to delimit this form. All the individuals we are referring to this species have one margin higher than the other. As has been pointed out by Branson and Mehl (Branson *et al.* 1938, p. 147) their *P. lobata* is close to *P. inornata*, and immature representatives of these two species are indistinguishable.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa. Recorded from the Bushberg, Hannibal and Chouteau of Missouri, a "Bushberg-Hannibal horizon" in Oklahoma, and thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana.

Figured Specimens.—State Univ. Iowa, 4121 (figs. 4, 5), 4122 (fig. 9), 4123 (fig. 13).

POLYGNATHUS LANCEOLATA E. R. Branson
Plate 16, figure 16

Polygnathus lanceolata E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 313, pl. 25, fig. 21.

Polygnathus lanceolata E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 132, 148, pl. 33, fig. 14; pl. 34, fig. 42

Polygnathus lanceolata E. B. BRANSON and MEHL, and E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, fig. 14; pl. 39, fig. 42.

Platform lanceolate in oral outline, slightly curved laterally. Each oral-lateral zone of the platform bears 10 to 12 large transverse or slightly oblique ridges which persist almost to the carina. The margins of the plate are somewhat curved orad in their anterior third. Carina low in central portion of platform, high anteriorly, and prominently nodose posteriorly. Blade rather high; denticles of blade fused essentially to their apices.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa. Also occurs

in the Hannibal and Chouteau formations of Missouri.

Figured Specimen.—State Univ. Iowa, 4124.

POLYGNATHUS LONGIPOSTICA
Branson and Mehl
Plate 15, figures 16–20

Polygnathus longipostica E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 294, pl. 24, figs. 8–11, 13.
Polygnathus longipostica E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 311, pl. 25, fig. 18
Polygnathus longipostica E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.
Polygnathus longipostica E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 132, pl. 33, fig. 53.
Polygnathus n. sp. KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.
Polygnathus longipostica COOPER, 1939, Jour. Paleontology, vol. 13, pp. 401, 420 pl. 39, figs. 31, 32, 43, 44.
Polygnathus longipostica HASS, 1943, Jour. Paleontology, vol. 17, p. 308.
Polygnathus longispostica E. B. BRANSON and MEHL, and E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, fig. 53.
Polygnathus longipostica YOUNGQUIST and MILLER, 1948, Jour. Paleontology, vol. 22, p. 448, pl. 68, fig. 12.

The collections under consideration contain a number of representatives of this species, three of which are illustrated. Although they differ somewhat in size, all of these specimens possess the general physiognomy of *P. longipostica* and in particular they exhibit the posteriorly extended carina with a prominent node and the aboral anteriorly attenuate blade (fig. 17 shows both features).

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa (fig. 19); similar horizon, southeastern Louisa Co., Iowa (fig. 18); similar horizon, northwestern Washington Co., Iowa (figs. 16, 17, 20). Also reported from the Sweetland Creek shale of Iowa, Bushberg and Hannibal strata in Missouri, a "Bushberg-Hannibal horizon" in Oklahoma, and a thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana.

Figured Specimens.—State Univ. Iowa, 4125 (figs. 16, 17), 4126 (fig. 18), 4127 (fig. 19), 4128 (fig. 20).

POLYGNATHUS MULTILIRATA Youngquist and Patterson, n. sp.
Plate 15, figures 21, 22

Holotype rather large. Plate very much longer than blade, broad, pointed posteriorly. Oral surface of plate prominently ornamented by relatively small transverse furrows and ridges which are arranged in a somewhat radiating manner from the central portion of the plate. Margin of the plate is strongly crenulate. Blade very short, high, and composed of only two or three large denticles. Posteriorly, the blade continues across the plate as a carina that is large and high anteriorly but becomes lower and somewhat nodose in its posterior portion. A large node is situated about midlength of the plate on the carina. Aborally, the plate and the blade are strongly keeled. This keel is interrupted slightly anterior on the plate, however, by a small elongate escutcheon.

Of previously described forms, only *P. corrugata* E. R. Branson appears comparable to *P. multilirata* n. sp. The former species may be distinguished from our *P. multilirata*, however, by its much more attenuate form.

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa.

Holotype.—State Univ. Iowa, 4129.

POLYGNATHUS PERPLANA E. R. Branson
Plate 17, figures 11, 12

Polygnathus perplana E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 309, pl. 25, fig. 7.
Polygnathus perplana E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 132.
Polygnathus perplana COOPER, 1939, Jour. Paleontology, vol. 13, pp. 402–403, 420, pl. 39, figs. 77, 78.
Polygnathus perplana E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221.

Our specimens are small, relatively slender, and suboval in oral plate outline. The blade is composed of about eight or nine almost entirely confluent denticles. The plate is somewhat longer than blade and bears a relatively large nodose carina. Entire specimen gently bowed and arched.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co. (fig. 11); similar horizon in southeastern Louisa Co., Iowa (fig. 12). The holotype of this species

came from the Hannibal formation of Missouri. Also recorded from a "Bushberg-Hannibal horizon" in Oklahoma.

Figured Specimens.—State Univ. Iowa, 4130 (fig. 11); 4131 (fig. 12).

POLYGNATHUS RADIOTOPLICATA Youngquist and Patterson, n. sp.
Plate 17, figures 18, 19

Oral outline of plate broadly suboval, somewhat more attenuate posteriorly than anteriorly. Blade relatively short, high, subtriangular in profile, composed of about six stout denticles which are confluent essentially to their apices. Oral ornamentation of plate consists of coarse, sinuous, radiating plications oriented with their long axes converging toward the central portion of the plate. A large, low carina is situated medianly and persists the entire length of the plate. Aborally, the holotype is smooth except for a large median keel, and a small escutcheon situated slightly anterior of midlength on the plate.

This species is somewhat similar to *P. multilirata* n. sp. but can be distinguished from it in that *P. radiotoplicata* has a more nearly radial plate ornamentation, a more prominent and distinct carina and a somewhat broader oral outline. In lateral outline the blades of these two specimens are quite different; that of *P. radiotoplicata* contains more denticles and is higher (cf. pl. 17, fig. 18 with pl. 15, fig. 22).

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4132.

POLYGNATHUS SAGITTARIA Youngquist and and Patterson, n. sp.
Plate 15, figures 9, 10;
Plate 16, figure 13

Holotype arrow-shaped in oral outline. Entire specimen very slightly bowed and arched. Blade short, plate long. Maximum width of plate is attained somewhat posterior of midlength. Plate margins moderately curved orad and finely crenulate. These crenulations persist essentially to the carina. The rather low blade is composed of some seven denticles which are distinct and partially discrete. Although the extreme anterior-aboral portion of the blade of the holotype is missing, that part of the specimen almost certainly was not particularly attenuate. The carina is large, essentially straight, and consists of about 15 to 17 nodes. A rather large, rounded escutcheon is present near the anterior end of the aboral surface of the plate. There is a large, sharp keel both anterior and posterior of the escutcheon on the plate and the blade is also sharpened aborally.

Superficially, in oral view, this species somewhat resembles the several specimens of *P. longipostica* Branson and Mehl which we are illustrating (pl. 15, figs. 16–20). However, *P. sagittaria* can be distinguished by its low lateral profile (caused chiefly by the shape of the blade), and the smaller and more numerous denticles composing the blade. Also, the oral surface of the plate is more deeply grooved and the crenulations of the plate margin are smaller.

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa (pl. 15, figs. 9, 10); similar horizon in southeastern Louisa Co., Iowa (pl. 16, fig. 13).

Types.—State Univ. Iowa, 4133 (holotype, pl. 15, figs. 9, 10), 4134 (paratype, pl. 16, fig. 13).

POLYGNATHUS SCOBINIFORMIS
E. R. Branson
Plate 17, figures 6–8

Polygnathus scobiniformis E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 314, pl. 25, fig. 23.

Polygnathus scobiniformis E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 133, pl. 33, fig. 16.

Polygnathus scobiniformis COOPER, 1939, Jour. Paleontology, vol. 13, pp. 403, 420, pl. 39, figs. 45–48.

Polygnathus scobiniformis E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, fig. 16.

Although our largest specimen (figs. 6, 7) is a reverse (i.e., a mirror-image of) the holotype, it is very similar to that form which was originally described from the Hannibal formation in northeastern Missouri, A lateral view (fig. 7) of this species illustrates its rather low, elongate profile.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa (figs. 6, 7); a similar horizon in northwestern Washington Co., Iowa (fig. 8). Originally described from the Hannibal formation of Missouri, and

also reported from a "Bushberg-Hannibal horizon" in Oklahoma.

Figured Specimens.—State Univ. Iowa, 4135 (figs. 6, 7), 4136 (fig. 8).

POLYGNATHUS cf. P. SUBSERRATA
Branson and Mehl
Plate 17, figure 10

The affinities of the illustrated specimen are somewhat uncertain. The plate margins are rather coarsely crenulate to the extent of being almost nodose. The carina is large and extends the entire length of the plate. It is nodose and is particularly so posteriorly. The blade is rather short and stout. Our specimen appears close to some of the other specimens from the Lower Mississippian which have been referred to this species. However, it does not seem to be particularly close to the syntypes of *P. subserrata* which came from the Grassy Creek shale of Missouri, a formation considered to be Upper Devonian in age.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Figured Specimen.—State Univ. Iowa, 4137.

POLYGNATHUS SUBTORTILIS Youngquist and Patterson, n. sp.
Plate 17, figure 3

Plate broad, becoming acuminate only near its posterior end. Carina is distinctive in that it is very high anteriorly, but in the midportion of the plate it is low and sinuous or twisted, being deflected laterally. Posteriorly the carina is somewhat nodose. In general, the ornamentation of the oral surface of the plate is coarse. The plate margins are prominently crenulated. Rugae traverse the plate somewhat obliquely toward (but usually do not reach) the carina. The blade is very short and high. Anteriorly it rises obliquely but abruptly to maximum height. Posteriorly the blade becomes progressively lower and is crenulated by three large denticles which compose it.

The sinuosity of the carina in the middle region of the plate is distinctive and serves to set this species aside from any other known forms. Also, the extreme shortness of the blade is noteworthy.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa.

Holotype.—State Univ. Iowa, 4138.

POLYGNATHUS SYMMETRICA E. R. Branson
Plate 15, figures 14, 15

Polygnathus symmetrica E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 310, pl. 25, fig. 11.

Polygnathus symmetrica E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 132, 146, pl. 33, fig. 11; pl. 34, fig. 33.

Polygnathus symmetrica E. B. BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 245, pl. 94, fig. 35.

Polygnathus symmetrica E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 221, pl. 32, fig. 11; pl. 39, fig. 33.

This species is abundant in our collection from Washington County. The relatively short thin blade and the pronounced symmetry of the illustrated specimen serve to indicate that it is referable to this Hannibal and Chouteau form.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa. Also recorded from the Hannibal and Chouteau formations of Missouri.

Figured Specimen.—State Univ. Iowa, 4139.

POLYGNATHUS UNDULOSA Youngquist and Patterson, n. sp.
Plate 17, figures 1, 2

Plate suboval in outline, slightly pointed posteriorly. Oral surface of plate bears large transverse ridges separated by narrow, shallow grooves. Carina prominent and composed of large partially fused nodes. Blade is relatively short, high, and somewhat attentuate in its anterior aboral portion. It is composed of five denticles, the anteriormost and posterior-most of which are the smallest. Aborally, there is a small escutcheon anterior of midlength on the plate Otherwise the aboral median longitudinal axis of the holotype is slightly keeled. The ovate outline of the plate and the broad, undulating, transverse ornamentation distinguish this species from congeneric forms.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4140.

PSEUDOPOLYGNATHUS AURITA Youngquist and Patterson, n. sp.
Plate 16, figures 5, 6

Plate outline in oral view asymmetrical; the outer side of the plate is broadly rounded whereas the inner side is sinuous in posterior

portion. Anteriorly, the inner side of the plate is much extended in a lateral-anterior direction to form an ear-like process. Orally, the plate is transversely rugose and is medianly marked by a large, stout carina which extends the entire length of the specimen. Blade nearly as long as plate. Although the oral surface of the blade is incomplete, the lower portions of five or six stout denticles are present. Aboral surface of plate bears a large anterior escutcheon which is not deep, and whose greater diameter is at right angles to the longitudinal axis of the specimen. A keel is well developed anteriorly and posteriorly from the escutcheon.

The inner lateral extended plate process is the most distinctive feature of this species. Some of the specimens of *Pseudopolygnathus distorta* described by Cooper (1939, pl. 40, figs. 49, 50) and *P. asymmetrica* E. R. Branson (1934, p. 320, pl. 26, fig. 12) are somewhat reminiscent of the illustrated holotype, but the inner anterior portion of the plate of our *P. aurita* is much more attenuate than is that feature on either of those species, or similar forms.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4141.

PSEUDOPOLYGNATHUS CARINATA Youngquist and Patterson, n. sp.
Plate 16, figure 4

Plate bluntly lanceolate in oral outline. Entire specimen gently arched and moderately bowed. Ornamentation of plate's oral surface dominated by a very large carina which persists medianly the length of the plate. Carina composed of closely fused nodes in its anterior portion, but posteriorly these nodes become somewhat discrete. Blade shorter than plate, stout, and composed of some five or six denticles. Denticles are fused nearly to their apices and serve merely to gently crenulate the oral blade margin. Aboral surface of plate bears an escutcheon of the type illustrated by *P. aurita*, n. sp. (see pl. 16, fig. 6). The pronounced rugose ornamentation characteristic of *Pseudopolygnathus* is somewhat subdued on this form.

The subdued rugose ornamentation, the blunt plate outline, and the prominent high carina serve to distinguish this species from congeneric forms.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Holotype.—State Univ. Iowa, 4142.

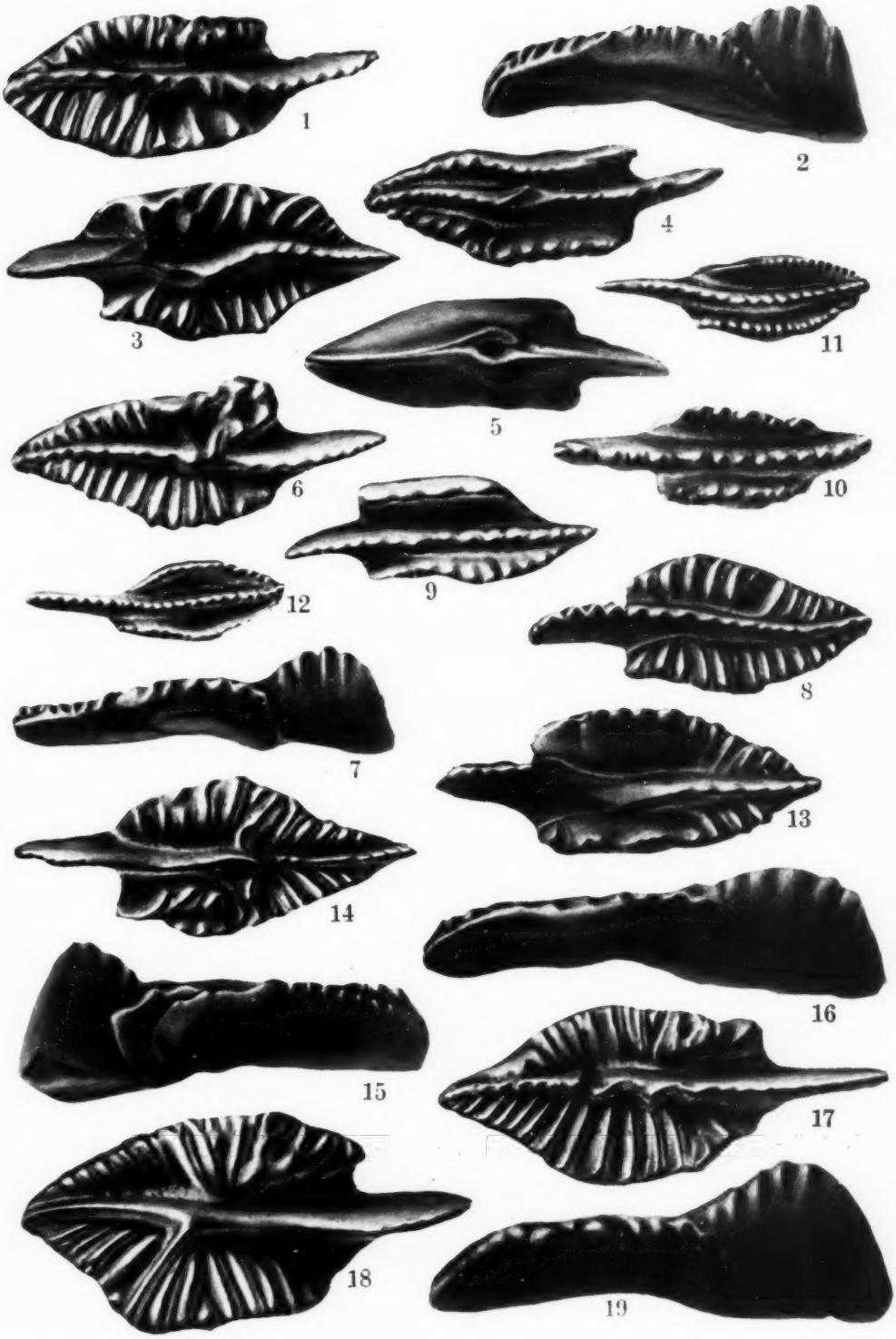
PSEUDOPOLYGNATHUS IRREGULARIS
E. R. Branson
Plate 16, figures 1–3

Pseudopolygnathus irregularis E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 316, pl. 26, figs. 25, 26.
Pseudopolygnathus irregularis E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 133.
Pseudopolygnathus irregularis COOPER, 1939, Jour. Paleontology, vol. 13, pp. 408, 420, pl. 40, figs. 21, 22, 25, 36.
Pseudopolygnathus irregularis E. R. BRANSON,

EXPLANATION OF PLATE 17

All specimens illustrated are from the Prospect Hill sandstone in southeastern Louisa County, Iowa, with the exception of figures *3, 8, 11*, which are from a similar horizon in northwestern Washington County, Iowa. All figures are ×25.

FIGS. *1, 2*—*Polygnathus undulosa* Youngquist and Patterson, n. sp. Oral and lateral views of the holotype. (p. 67)
3—*Polygnathus subtortilis* Youngquist and Patterson, n. sp. The holotype. (p. 67)
4, 5—*Polygnathus inornata* E. R. Branson. See also figs. 9, 13. (p. 64)
6–8—*Polygnathus scobiniformis* E. R. Branson. (p. 66)
9—*Polygnathus inornata* E. R. Branson. See also figs. *4, 5, 13*. (p. 64)
10—*Polygnathus* cf. *P. subserrata* Branson and Mehl. (p. 67)
11, 12—*Polygnathus perplana* E. R. Branson. Oral views of specimens from two localities. (p. 65)
13—*Polygnathus inornata* E. R. Branson. See also figs. *4, 5, 9*. (p. 64)
14, 15—*Polygnathus cymbiformis* Youngquist and Patterson, n. sp. The holotype. (p. 62)
16, 17—*Polygnathus hannibalensis* Youngquist and Patterson, n. sp. Two views of the holotype. (p. 63)
18, 19—*Polygnathus radiotoplicata* Youngquist and Patterson, n. sp. Oral and lateral views of the holotype. (p. 66)



Youngquist and Patterson, Lower Mississippian Conodonts

1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 222.

Plate transversely rugose on its oral surface, divided medianly by a prominent carina. Blade stout, composed of about five short denticles. Aboral surface of plate bears a rather large escutcheon which is located anteriorly and has its longest axis normal to the long axis of the conodont. Anterior and posterior to the escutcheon the specimen is strongly keeled. Our illustrated specimen appears to be very similar to the holotype of this species from the Hannibal formation of Missouri.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa. Also known from the Hannibal formation of Missouri and a "Bushberg-Hannibal horizon" in Oklahoma.

Figured Specimen.—State Univ. Iowa, 4143.

SIPHONODELLA DUPLICATA
(Branson and Mehl)
Plate 16, figures 7–10

Siphonognathus duplicata E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, pp. 295, 296, 297, pl. 24, figs. 16, 17.
Siphonognathus duplicata E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 315, pl. 25, figs. 1, 13–16.
Polygnathus plana HUDDLE, 1934, Bull. Amer. Paleontology, vol. 21, no. 72, pp. 17, 103–104, pl. 8, figs. 39–43.
Siphonognathus duplicata E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 131, 133, 136, 148, pl. 33, fig. 17; pl. 34, figs. 34, 35.
Siphonognathus duplicata KNECHTEL and HASS 1938, Jour. Paleontology, vol. 12, p. 519.
Siphonognathus quadruplicata [part] COOPER, 1939, Jour. Paleontology, vol. 13, pp. 409, 420, pl. 41, figs. 44, 45.
Siphonognathus duplicata HASS, 1943, Jour. Paleontology, vol. 17, p. 308.
Siphonodella duplicata E. B. BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 245.
Siphonognathus duplicata E. B. BRANSON and MEHL, and E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 222, pl. 32, fig. 17; pl. 39, figs. 34, 35.

This species is common in our collections and the forms which we are illustrating compare closely with the syntypes. Though no aboral views are shown, our specimens likewise possess essentially no escutcheon or keel, and, as Branson and Mehl indicate for this species (1934, p. 297), "the aboral side is nearly smooth." The specimen illustrated by Cooper (1939, pl. 41, figs. 44, 45) and referred to *S. quadruplicata* appears to bear only a single ridge on either side of the anterior portion of the carina and therefore its reference to *S. duplicata* seems more nearly certain.

Occurrence.—The illustrated specimens are from the Prospect Hill sandstone, southeastern Louisa Co., Iowa. Unfigured specimens have been secured from the type section of the Prospect Hill sandstone, Burlington, Iowa, and a similar horizon in northwestern Washington Co., Iowa. Also reported from Bushberg, Hannibal, and Chouteau beds in Missouri, a "Bushberg-Hannibal horizon" in Oklahoma, and a thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana. Branson and Mehl (1944, p. 245) add that it is known from the basal Rockford of Indiana and the Welden of Oklahoma.

Hypotypes.—State Univ. Iowa, 4144 (fig. 7), 4145 (fig. 8), 4146 (figs. 9, 10), 4147 (unfigured specimen from type section at Burlington, Iowa), and 4148 (unfigured specimen from the Washington Co. locality).

SIPHONODELLA PONDEROSA Youngquist and Patterson, n. sp.
Plate 16, figure 17

Plate large, thick. Blade short, subtriangular in lateral outline, moderately high, composed of about eight denticles which are confluent nearly to their apices. Carina on portion of plate adjacent to blade is distinctly ridge-like but posteriorly it becomes discontinuous persisting in the form of lineally arranged, low, rather well separated nodes. Plate margins are very much thickened; outer margin of plate laterally flared at approximately midlength; inner margin rather uniformly rounded. Aborally the plate is smooth except for a small keel beneath the blade and a very small escutcheon centrally located on the plate.

This species is much coarser and more massive in form than congeneric specimens. It is perhaps closest to the specimen from the upper New Albany shale described by Huddle (1934) as *Polygnathus plana* and

illustrated on his plate 8, figures 41, 42.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa.

Types.—State Univ. Iowa, 4149 (illustrated holotype), 4150 (unfigured paratype).

SIPHONODELLA QUADRUPLICATA
(Branson and Mehl)
Plate 16, figure 11

Siphonognathus quadruplicata E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, pp. 295–296, 297, pl. 24, figs. 18, 21.

Siphonognathus quadruplicata E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 315.

Polygnathus newalbanyensis HUDDLE, 1934, Bull. Amer. Paleontology, vol. 21, no. 72, pp. 17, 101, pl. 8, figs. 27, 28.

Siphonognathus quadruplicata E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.

Siphonognathus quadruplicata E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 131, pl. 33, figs. 57, 58.

Siphonognathus quadruplicata KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.

Siphonognathus newalbanyensis [part] COOPER, 1939, Jour. Paleontology, vol. 13, pp. 409, 420, pl. 41, figs. 21, 22.

Siphonognathus isolopha [part] COOPER, 1939, Jour. Paleontology, vol. 13, pp. 409, 420, pl. 41, figs. 5, 6 [not figs. 19, 20].

Siphonognathus quadruplicata [part] COOPER, 1939, Jour. Paleontology, vol. 13, pp. 409, 420 [not pl. 41, figs. 44, 45].

Siphonognathus quadruplicata HASS, 1943, Jour. Paleontology, vol. 17, p. 308.

Siphonodella quadruplicata E. B. BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 245, pl. 94, figs. 44, 45.

Siphonognathus quadruplicata E. B. BRANSON and MEHL, 1944, *in* E. B. Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 222, pl. 32, figs. 57, 58.

Siphonodella quadruplicata HASS, 1947, Jour. Paleontology, vol. 21, p. 137.

In accordance with Branson and Mehl's interpretation of this genus, we are utilizing the longitudinal plications or ridges on either side of the carina for specific identifications. Though varying somewhat in other features, the conodonts exhibit these plications with fair consistency. When this criterion is applied, specimens which have been referred to several other species appear to fall well within the limits of *S. quadruplicata*.

Occurrence.—Figured specimen is from the Prospect Hill sandstone, northwestern Washington Co., Iowa. Unfigured specimens have been secured from the type section of the Prospect Hill member at Burlington, Iowa, and a similar horizon in southeastern Louisa Co., Iowa. Also reported from Bushberg and Hannibal beds in Missouri; the upper New Albany shale of Indiana; the upper Sunbury shale of Ohio; a "Bushberg-Hannibal horizon" in Oklahoma, and a thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana.

Hypotypes.—State Univ. Iowa, 4151 (figured specimen), 4152 (unfigured specimen from type section at Burlington, Iowa), and 4153 (unfigured specimen, Louisa Co. locality).

SIPHONODELLA SEXPLICATA
(Branson and Mehl)
Plate 16, figure 12

Siphonognathus sexplicata BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, pp. 295, 296, pl. 24, figs. 22, 23.

Polygnathus newalbanyensis [part] HUDDLE, 1934, Bull. Amer. Paleontology, vol. 21, no. 72, pp. 17, 101, pl. 8, fig. 26 [not 27, 28?].

Siphonognathus sexplicata BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.

Siphonognathus sexplicata BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, pp. 129, 130, 131, 136, pl. 33, fig. 59.

Siphonognathus n. sp. KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.

Siphonognathus sexplicata COOPER, 1939, Jour. Paleontology, vol. 13, pl. 41, figs. 3, 4, 7, 8, 38, 39.

?Siphonognathus cf. *S. sexplicata* COOPER and SLOSS, 1943, Jour. Paleontology, vol. 17, pp. 171, 174, pl. 29, fig. 30.

Siphonognathus sexplicata HASS, 1943, Jour. Paleontology, vol. 17, p. 308.

Siphonognathus sexplicata BRANSON and MEHL, 1944, *in* E. B. BRANSON, Missouri Univ. Studies, vol. 19, no. 3 p. 222, pl. 32, fig. 59.

Although in somewhat subdued form, the illustrated specimen possesses the three longitudinal plications characteristic of the species. Branson and Mehl (1938, p. 129) have indicated that *S. sexplicata* is indicative of the Bushberg. They state "although there are few species of *Siphonognathus*, one of these, *S. sexplicata*, is a fine horizon marker. It is widespread in its distribution, is easily recognized and seems to be confined to the Bushberg and its exact time equivalents." They add (p. 130) that a "diligent search has failed to produce from the Hannibal the common Bushberg species *Siphonognathus sexplicata*."

Siphonodella duplicata is very abundant and *S. quadruplicata* and *S. sexplicata* are not uncommon in the Prospect Hill sandstone at the outcrops located in the northwestern portion of Washington Co., Iowa. *S. sexplicata* also occurs in the type section at Burlington, Iowa. Presumably, therefore, the Bushberg horizon is represented at these two localities. Though in all other respects the fauna is very much the same as at the type section of the Prospect Hill, *S. sexplicata* has not been found at the Louisa Co. locality though *S. quadruplicata* and *S. duplicata* are fairly common. *S. sexplicata* may possibly be a Bushberg horizon marker, but we cannot in any other way distinguish the conodont faunas secured from the Washington County outcrop and the type section at Burlington, Iowa, (containing *S. sexplicata*) from the assemblage secured at the Louisa County locality. Furthermore, the assemblages from all of these places are strikingly that of the Hannibal formation. Since the Bushberg is at least partially equivalent to the Hannibal, it is quite possible that the Bushberg and the Hannibal conodont zones (if they can be determined at some localities) will be at least in part contemporaneous at other outcrops.

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa, and a similar horizon in northwestern Washington Co., Iowa. Originally described from the Bushberg sandstone of Missouri. Also reported from the upper New Albany shale of Indiana, a "Bushberg-Hannibal horizon" in Oklahoma, and a thin shale at the base of the Lodgepole limestone, Little Rocky Mountains, Montana. It may possibly occur in a "Lower Mississippian black shale," Big Snowy Mountains, Montana.

Hypotypes.—State Univ. Iowa. 4154 (figured specimen from Washington Co.), 4155 (unfigured specimen from Washington Co.), 4156 (unfigured specimen from type section at Burlington, Iowa).

SPATHOGNATHODUS ACIEDENTATUS
(E. R. Branson)
Plate 15, figure 3

Spathodus aciedentatus E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 306, pl. 27, figs. 21, 23.

Spathodus aciedentatus E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 132.

Spathodus aciedentatus COOPER, 1939, Jour. Paleontology, vol. 13, pp. 413, 420, pl. 45, figs. 26, 28, 44.

Spathognathodus aciedentatus COOPER and SLOSS, 1943, Jour. Paleontology, vol. 17, pp. 171, 174, pl. 28, fig. 2.

Spathognathodus aciedentatus E. R. BRANSON, 1944, *in* E. B. Branson, Missouri Univ. Studies vol. 19, no. 3, p. 223.

Spathognathodus aciedentatus HASS, 1947, Jour. Paleontology, vol. 21, p. 136.

Blade moderately bowed and gently arched. Anterior margin of blade nearly perpendicular to the lower edge of blade. Denticles are partially discrete, and slightly rounded distally though in general compressed laterally. The penultimate anterior denticle is distinctly larger than any of the others. The figured specimen does not seem to differ materially from the syntypes of this species and is particularly close to the specimen illustrated by E. R. Branson's figure 21 on plate 27, of 1934.

Occurrence.—Prospect Hill sandstone, northwestern Washington Co., Iowa. The types came from the Hannibal formation of Missouri. Also reported from the basal Orangeville and basal Sunbury shales of Ohio, a "Bushberg-Hannibal horizon" in Oklahoma, and a "Lower Mississippian black shale," Big Snowy Mountains, Montana.

Figured Specimen.—State Univ. Iowa, 4157.

SPATHOGNATHODUS CRASSIDENTATUS
(Branson and Mehl)
Plate 15, figure 2

Spathodus crassidentatus E. B. BRANSON and MEHL, 1934, [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 276, pl. 22, figs. 17, 18.

Spathodus crassidentatus E. R. BRANSON, 1934, [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 303, pl. 27, fig. 12.

Spathodus parvus HUDDLE, 1934, Bull. Amer. Paleontology, vol. 21, no. 72, pp. 16, 90–91, pl. 7, fig. 16.

Spathodus crassidentatus E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.

Spathodus crassidentatus E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 132, pl. 33, fig. 5.

Spathodus crassidentatus COOPER, 1939, Jour. Paleontology, vol. 13, pp. 413, 420, pl. 45, fig. 19.

Spathodus crassidentatus COOPER and SLOSS, 1943, Jour. Paleontology, vol. 17, pp. 171, 175, pl. 28, fig. 1.

Spathognathodus crassidentatus E. B. BRANSON and MEHL, and E. R. BRANSON, 1944, *in* E. B.

Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 223, pl. 32, fig. 5.

The figured specimen is very close to the particular syntype of this species illustrated by Branson and Mehl's figure 17 on their plate 22 of 1934. Though the adoral portions of some of the denticles are missing on our specimen, the initial presence of the two high denticles (as in the cited syntype) on the anterior part of the blade is plainly indicated, and the specific reference of this form seems clear.

Occurrence.—Type section of Prospect Hill sandstone, Burlington, Iowa. The syntypes came from the Bushberg sandstone of Missouri. Conspecific individuals have been reported from the Hannibal formation of Missouri, the upper New Albany shale of Indiana, a "Bushberg-Hannibal horizon" in Oklahoma, and a "Lower Mississippian black shale," Big Snowy Mountains, Montana.

Figured Specimen.—State Univ. Iowa, 4158.

SPATHOGNATHODUS SULCIFERUS
(Branson and Mehl)
Plate 15, figure 1

Spathodus sulciferus E. B. BRANSON and MEHL, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 274, pl. 22, figs. 12, 13.
Spathodus sulciferus E. R. BRANSON, 1934 [1933], Missouri Univ. Studies, vol. 8, no. 4, p. 304, pl. 27, figs. 15, 20, 22.
Spathodus sulciferus E. B. BRANSON, 1938, Missouri Univ. Studies, vol. 13, no. 3, p. 182.
Spathodus sulciferus E. B. BRANSON *et al.*, 1938, Missouri Univ. Studies, vol. 13, no. 4, p. 132, pl. 33, fig. 33.
Spathodus n. sp. KNECHTEL and HASS, 1938, Jour. Paleontology, vol. 12, p. 519.
Spathodus sulciferus COOPER, 1939, Jour. Paleontology, vol. 13, pp. 416, 420, pl. 45, figs. 17, 18.
Spathognathodus sulciferus HASS, 1943, Jour. Paleontology, vol. 17, p. 308.
Spathognathodus sulciferus E. B. BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 244, pl. 94, fig. 2.
Spathodus sulciferus E. B. BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 223, pl. 32, fig. 33.
Spathognathodus sulciferus E. B. BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 223.

Blade essentially straight and only slightly uparched. Denticles partially fused and somewhat offset with some toward the inner side of the blade and others toward the outer. In the region directly orad of the escutcheon there are two or three particularly large and discrete denticles.

Our specimen appears closer to *S. sulciferus* Branson and Mehl than to any other form now known. Branson and Mehl state that the species is notably abundant and variable in the basal Kinderhook. It appears that our Prospect Hill specimen falls well within the limits of that species as now interpreted by various authors. It should be noted that this specimen is somewhat incomplete anteriorly but the fractured margin suggests the initial presence of the high blade characteristic of the syntypes.

Occurrence.—Prospect Hill sandstone, southeastern Louisa Co., Iowa; Bushberg, Hannibal, and Chouteau strata in Missouri; and a "Bushberg-Hannibal horizon" in Oklahoma.

Figured specimen.—State Univ. Iowa, 4195.

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MANUSCRIPT RECEIVED MAY 8, 1948

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 74–80, PLS. 18–20, 2 TEXT FIGS., JANUARY 1949

NEW GENERA OF DEVONIAN NAUTILOIDS

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ABSTRACT—Four new genera, *Tumidoceras*, *Diademoceras*, *Muiroceras*, *Haydenoceras*, are described from material of Devonian age. Their genotypes are described and illustrated.

The present paper contains descriptions of new Devonian genera of more than usual interest, together with the species upon which they are based. *Diademoceras*, based upon *D. palmeri* of the Cherry Valley limestone of New York, was previously described briefly in connection with a discussion of the frilled and spined gyroceracones of the Devonian (Flower, 1945). The genotype had not been described in detail nor illustrated, because it was included in a manuscript which had been awaiting publication as a bulletin of the New York State Museum since 1941. *Muiroceras*, from the Middle Devonian of Alaska is a bizarre type combining the form and structure, except for the non-actinosiphonate siphuncle, of *Cyrtoceras*, with nodes generally characteristic of orthochoanitic and more slender gyroceracones. *Haydenoceras*, of the Devonian of Nevada, a striking compressed cyrtocone which I have not encountered elsewhere in the American Devonian, appears to be derived from the Silurian genus *Laureloceras*, but is homeomorphic to some degree with *Exomegoceras* and *Digenuoceras* of the Oncoceratidae. *Tumidoceras* of the Michigan Devonian, is an anomalous breviconic type differing from most of the larger Devonian brevicones in the compressed instead of depressed section. Superficially similar to *Alpenoceras*, it is distinguished from that genus by the ventral position of the siphuncle as well as the lateral saddles of the sutures.

I am indebted to the U. S. National Museum for the opportunity to study most of the material upon which this paper is based.

Genus DIADEMOCERAS Flower
Genotype: *Diademoceras palmeri* Flower n. sp.

Diademoceras FLOWER, 1945. Amer. Midl. Nat., vol. 33, p. 677.

Conch gyroceraconic, probably not of more than two volutions, whorl broadly depressed in section, the dorsum flattened, sides converging ventrad and meeting in a strongly developed ventral keel. The conch is ornamented by a single series of spines on each side. Other surface markings consist of transverse striae which slope apicad on the venter to form a well developed hyponomic sinus.

The sutures are straight and transverse ventrally, but form broad shallow lobes on the dorsum. The siphuncle, not observed in the genotype, is close to the venter, orthochoanitic and empty.

Discussion.—The single row of lateral spines recalls *Trochoceras* and *Ptenoceras* in which, however, the section is evenly rounded on dorsum and venter, and solid spines instead of spout-like processes appear. These are reflected on the interior by only very faint lateral nodes. *Halloceras* differs in the absence of solid spines and also in the section of the shell, which is flattened ventrally and strongly rounded dorsally. In internal features and the solid spines this genus suggests *Tetranodoceras* from which it differs in the presence of a single pair of lateral spines, and the strongly keeled venter. This last difference is not constant. One mature specimen of *Tetranodoceras transversum* is known which develops a ventral keel in the gerontic stage, though only over

a very short interval of the shell.

The genus *Diademoceras* is represented by a single species from the Cherry Valley limestone of New York. Several additional species occur in the Manitoban limestone of the Lake Winnipegosis area, among them *Diademoceras submamillatum* (Whiteaves). Other species from the same formation await description.

DIADEMOCERAS PALMERI Flower, n. sp.
Plate 18, fig. 7; Plate 19, figs. 2–3

This is a moderate sized gyroceracone which when complete must have described nearly two volutions, and must have developed a coil 150 mm. across. The holotype, the only specimen observed, is a fragment 140 mm. in length, describing somewhat less than a quarter of a volution, and retaining a submature living chamber and a portion of the phragmocone. The section is broadly flattened, the dorsum flat ventrally, the sides strongly rounded laterally, and converging with decreased curvature toward the ventral keel. In 40 mm. the diameters increase from 32 mm. and 52 mm. to 34 mm. and 56 mm., in the length of the phragmocone. The living chamber has a length of 55 mm., and attains apertural diameters of 65 mm. and 42 mm.

The sutures are straight and transverse ventrally and laterally, but develop slight lobes on the dorsum. Six camerae occur in a length equal to the adoral transverse diameter of 56 mm., and four in a length equal to the corresponding vertical diameter of 36 mm. The last camera is slightly contracted, indicating the approach of a mature condition.

The ornament consists of transverse lirae and striae which form a broad subangular hyponomic sinus which occupies the entire ventral surface. The lateral margins of the shell bear a single pair of rows of solid nodes spaced so that one occurs on every third camera. The nodes are directed slightly anteriorly.

The aperture is somewhat weathered on the holotype. Its form is shown by the lines of growth on the earlier part of the shell. The dorsal part of the aperture, not clearly indicated on the specimen, is probably straight and transverse, as suggested by its condition in congeneric forms.

Discussion.—This form is small and slender in contrast to the only similar species previously described, *Diademoceras submamillatum* (Whiteaves). Singularly enough this species in the Cherry Valley strengthens the affinities shown by its cephalopods with the fauna of the Lake Winnipegosis region. However, most other forms of the Cherry Valley are related to species of the Winnipegosis dolomite. This is a genus which is known only from the overlying Manitoban limestone.

Type.—Holotype, Paleontological Research Institution, no. 5971.

Occurrence.—From the Cherry Valley limestone, road cut along Oneida Creek above Stockbridge Falls, Madison County, New York. The type was collected by the writer and Professor E. L. Palmer of Cornell University, for whom the species is named.

Genus HAYDENOCERAS Flower, n. gen.
Genotype: *Haydenoceras acutum*
Flower, n. sp.

Conch cyrtoconic, very gradually expanding. Cross section cuneate, very strongly compressed, the dorsum strongly rounded, the venter acutely angled. The sutures form lateral lobes separated by a high subangular ventral saddle and a lower, more rounded dorsal saddle. The siphuncle, incompletely observed, appears to be tubular and is located close to the venter. The surface bears rugose lines of growth becoming costate in the adult, which slope apicad strongly from dorsum to venter, and are strongly oblique over the lateral faces and slightly curved, the convex side being directed orad.

Discussion.—This genus is erected for the reception of a single Devonian species which appears to have no close relatives, and is at present of uncertain affinities. Genera agreeing with it in the striking compressed cuneate cross section are clearly not closely related, as shown by their cyrtochoanitic and broadly expanded siphuncles. *Oxygonioceras* Foerste of the Silurian of America and Europe differs mainly in the very broadly expanded siphuncle which suggests a relationship with *Oonoceras* of the Onoceratidae rather than with an orthochoanitic line. *Digenuoceras* Foerste of the American Ordovician is even more strikingly compressed,

the cross section being angled on the dorsum as well as on the venter. This genus also is cyrtochoanitic and allied to *Oonoceras*. *Exomegoceras* Miller and Carrier agrees with *Haydenoceras* more closely in the cross section of the shell, but is closely septate, the siphuncle is somewhat expanded within the camerae, and species of this genus are not far removed from Ordovician and Silurian species which I have placed in *Oonoceras*. None of these genera agree with *Haydenoceras* in the strongly oblique and rugose surface markings. Instead the evidence suggests that *Haydenoceras* is more probably related to the Silurian genus *Laureloceras* Flower, with which it agrees in the features of the phragmocone. The cross section of *Laureloceras* is not strongly enough compressed to cause the venter to develop an acute angle, and the surface is essentially smooth.

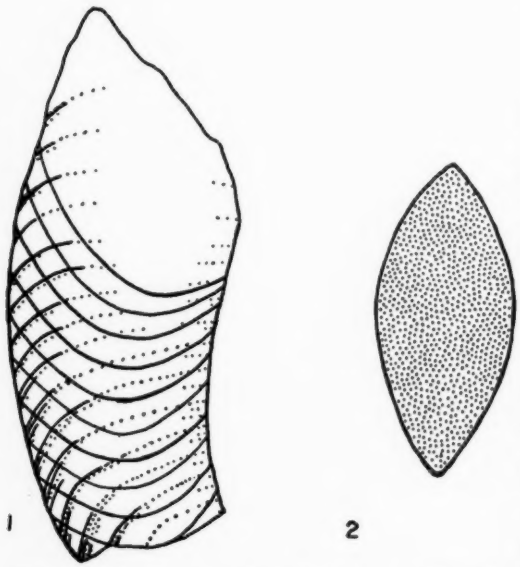


FIG. 1—Outline drawing of lateral view of *Haydenoceras acutum* paratype, ×1.
FIG. 2—Cross section of *Haydenoceras acutum*, ×1.

HAYDENOCERAS ACUTUM Flower, n. sp.
Plate 18, fig. 1–3; Text figs. 1, 2

The holotype is a small aseptate conch 57 mm. in length, part of the venter of which is removed by weathering. The radius of curvature of the venter increases from 55 mm. to 65 mm. in the length of the specimen, with a ventral length of 57 mm. At the base the section is 15 mm. high and only 5 mm. wide, the greatest width occurring dorsad of the center of the section. At the adoral end the width is 13 mm. and the height 18 mm. The surface bears rugose lines of growth, varying irregularly in strength and prominence, sloping apicad strongly from the dorsum to the venter, and becoming increasingly inflected apicad as they approach the venter.

A paratype representing a considerably larger individual fails to show the diagnostic surface markings as clearly, but supplies the features of the phragmocone. This specimen increasing in height from 22 mm. to 30 mm. in the basal 45 mm., contains five camerae in a length of 20 mm. The siphuncle is represented by a small perforation close to the ventral wall of the shell. Internal preservation seems too poor to warrant an attempt to study it by sections. In this specimen the rugose growth markings shown on the younger holotype have developed into faint costae, and they are somewhat more transverse dorso-laterally, the obliquity being confined to the ventral half of the shell.

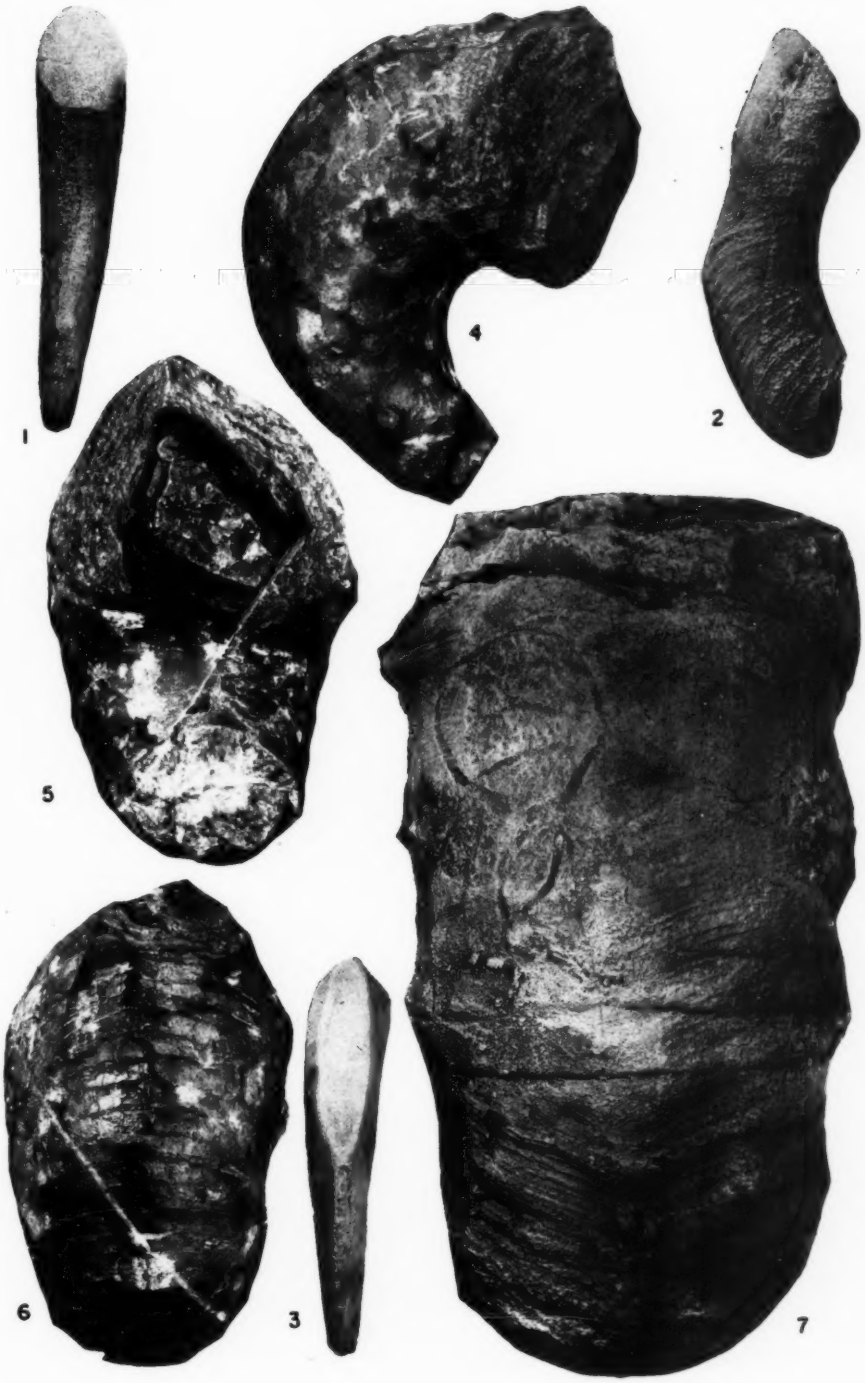
Discussion.—The characters of the genus

EXPLANATION OF PLATE 18

FIGS. *1–3*—*Haydenoceras acutum* Flower, n. sp. Holotype ×1, *1*, ventral, *2*, lateral and *3*, dorsal views. Nevada limestone, Lone Mt., Nevada. U. S. National Museum no. 13986. (p. 76)

4–6—*Muiroceras tuberculosum* Flower, n. sp. Holotype, U. S. National Museum, *4*, lateral, *5*, dorsal, *6*, ventral views, natural color. ×1. Middle Devonian, Long Island, Kasaan Bay, Alaska. (p. 77)

7—*Diademoceras palmeri* Flower, n. sp. Holotype, ventral view, ×1. Paleontological Research Institution, no. 5971. Cherry Valley limestone, Stockbridge Falls, Oneida Creek, N. Y. (p. 75)



Flower, New Devonian Nautiloid Genera

Flower, New Devonian Nautiloid Genera

will serve to distinguish the species at the present time. The species is known to me from several fragmentary specimens from the Roberts Mountains region.

Types.—Holotype, U. S. National Museum, no. 13986. Paratype. Collection of C. W. Merriam.

Occurrence.—Devonian, Nevada limestone formation, Roberts Mountains, Nevada. The holotype is from Lone Mountain.

Genus MUIROCERAS Flower, n. gen.
Genotype: *Muiroceras tuberculosum* Flower, n. sp.

Conch strongly curved, nearly gyroceraconic when complete, rapidly expanding, depressed in section, the dorsum more flattened than the venter, expanded more rapidly transversely than vertically in growth. The sutures are faintly oblique, rising on the venter to form low saddles. Dorsally the sutures have not been observed. The siphuncle is composed of broad short nummuloidal segments, barrel-shaped, about as wide as long. No organic deposits are seen in the siphuncle. The surface shell is faintly marked with transverse lines of growth. On the sides these are modified to form rounded tubercles. The growth lines bend downward around and below the tubercles as in the bases of the alate expansions of *Ptenoceras* and its allies.

Discussion.—The single paired series of lateral tubercles suggests *Ptenoceras* and its allies, but in those shells the conch is slender, the siphuncle is orthochoanitic or at least very slender. Further, the rapid expansion of the shell of *Muiroceras*, the close septation and the large nummuloidal ventral siphuncle are features which suggest instead a group of shells ordinarily not decorated with nodes or spines. There is a strong superficial similarity to the Ordovician genus *Valcouroceras*, and also to the actinosiphonate European Devonian genus *Cyrtoceras* Goldfuss. *Muiroceras* differs from *Cyrtoceras* mainly in the presence of tubercles and the absence of actinosiphonate structure within the siphuncle. As actinosiphonate structure may behave in a very erratic manner, both among individuals of a species and among a series of closely related species, I am inclined to believe that this genus is a nodose expression of *Cyrtoceras*. The two genera are very similar in section, the course and close spacing of the sutures, while no forms among the nodose or alate gyroceracones are particularly similar to *Muiroceras* other than in the development of nodes, a feature which may clearly be superficial. The genus is known to me only from the genotype, described more fully below.

MUIROCERAS TUBERCULOSUM Flower, n. sp.
Plate 18, figs. 4–6; Plate 20, figs. 1, 4.

The type and only known specimen is a portion of a gyroceracone describing about half a volution, and with a maximum length of 70 mm. Near the base the shell is 25 mm. wide and 20 mm. high, but part of the venter, perhaps as much as 4 mm., is lost except at the extreme base where the dorsum is missing and measurement cannot be taken. In a ventral length of 70 mm. the shell has increased to a height of 32 mm. and a width of 38 mm. Adorally the height increases to 38 mm, where the width is not completely preserved, but the proportions evidently are either the same or the width becomes still greater in proportion to the height of the shell. This point is 30 mm. farther as measured on the curving venter, and about 20 mm. prior to the base of the living chamber.

The camerae are obscure basally. In the middle of the shell, seventeen subequal camerae occupy a ventral length of 70 mm. In this interval the shell width increases from 32 mm. to 42 mm. The sutures slope slightly orad on the venter. Laterally and dorsally

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EXPLANATION OF PLATE 19

FIG. *1*—*Tumidoceras magnum* Flower, n. sp. Holotype, U.S. National Museum, lateral view, slightly reduced. Gravel Pt. formation, Petoskey Portland Cement Co. quarry, near Petoskey, Mich. (p. 79)

2–3—*Diademoceras palmeri* Flower, n. sp. Holotype, ×⅔, lateral and dorsal views. Paleontological Research Institution. Cherry Valley limestone, Stockbridge Falls, Oneida Creek, N. Y. (p. 75)

they have not been preserved, being covered by the shell, and slight etching has failed to reveal them. The venter shows clearly the position of the siphuncle by a darkening of the calcite of the camerae. At the extreme base of the specimen the segments appear to be fusiform, higher than long, but definitely expanded in the camerae, and with no trace of actinosiphonate deposits. Over the greater part of the shell the segments are broad, as wide as long, faintly expanded within the camerae. A segment 4 mm. long increases from 3.5 mm. in width at the septal foramen to 4.5 mm. within the camerae. The septal neck is recurved, but free and not recumbent. The connecting ring is relatively thick, but has produced no actinosiphonate rays. The interior of the siphuncle of the type is divided into a light and a dark area, but the divisions are lateral, and are clearly features pertaining to the complement of calcite of an incomplete internal mold of black lime mud, and have nothing to do with the structure of the organism.

Nothing is known of the living chamber except its extreme base. If the shell expanded to the aperture uniformly the conch was a very short, rapidly expanding one. Brevoniconic living chambers are not known in connection with nodose or alate shells such as this.

The surface markings consist of fine lines of growth on the dorsal region, which curve apicad laterally, more steeply around the nodes than elsewhere. Four nodes are clearly preserved on one side of the shell, their centers about 15 mm. apart. These structures were clearly solid nodes and neither hollow spines nor alate expansions.

Discussion.—The type and only known specimen, though clearly a fragment of a much larger and more imposing shell, presents characters which set it apart from all previously known nautiloids, the most conspicuous features being the combination of nodes more generally characteristic of slender and orthochoanitic shells, in a broadly expanded cyrtochoanitic conch. Assuming uniform expansion to the aperture and a reasonable length for the living chamber, the coil of the complete shell was probably 120 mm. in circumference and the shell width must have been close to 90 mm.

The type has been slightly retouched in our illustrations. The phragmocone was filled with calcite showing sutures and other characters by color variation rather than relief. Yet the effect of weathering, a calcite vein through the specimen, and adherent portions of the matrix made photography in natural color rather unsatisfactory. The type was labeled *Ooceras sp.* and is apparently the basis of this citation in Kindle's faunal list for the upper part of his Devonian section of Long Island (Kindle, 1907, p. 327).

Holotype.—U. S. National Museum.

Occurrence.—Long Island, Kasaan Bay, Alaska. E. M. Kindle coll., U. S. Nat. Museum no. 818. From C of Kindle's section, comprising the upper 270 ft. of the 560 foot section of Devonian limestone (Kindle, 1907, pp. 325, 327).

Genus TUMIDOCERAS Flower, n. gen.
Genotype: *Tumidoceras lentum* Flower, n. sp

Conch exogastric, enlarging slowly to a living chamber of fusiform outline, contracted gradually and slightly toward aperture which is transverse, wide, and marked only by a shallow hyponomic sinus. The cross section is higher than wide, the venter obscurely angled, sides rounded, dorsum somewhat flattened. Sutures develop faint broad saddles laterally, a very broad faint dorsal lobe, but are essentially transverse over the ventral surface. The siphuncle is ventral, nummuloidal, the segments broad. Organic deposits in siphuncle not observed.

Discussion—This genus contains some brevicones which differ from most of their associates in the Devonian in the compressed instead of depressed section. In aspect the genus bears a superficial resemblance to *Cyrtogomphus* particularly in simplicity of form, but the suture pattern is more complex and the section compressed. *Brevicoceras* is broader than high, lacks prominent lateral saddles, but has a somewhat similar, though more pronounced dorsal lobe.

This genus is erected for the reception of two species from the Devonian of Michigan.

TUMIDOCERAS LENTUM Flower, n. sp.
Plate 20, figs. 2, 3.

Conch faintly exogastric, the adoral portion faintly fusiform. The type retaining the living chamber and a portion of the phragmocone, 90 mm. long ventrally, presents a faintly and uniformly convex ventral pro-

file, while the dorsum diverges from the venter to the base of the living chamber, then curves slightly so that it approaches it gradually to the aperture. The sides diverge, but are faintly convex so that the angle of divergence decreases over the living chamber. The sutures are transverse ventrally, rising into broad low saddles in the lateral region and describe a broad shallow lobe over the dorsum. Eight subequal camerae occupy the lower part of the type, followed by a gerontic camera half the length of the others. The siphuncle is close to the venter, compressed in section at the septal foramen. Its structure has not been observed. The type expands from 50 mm. to 58 mm. vertically in the 45 mm. of the phragmocone and contracts to 48 mm. at the aperture, the living chamber having a ventral length of 45 mm. and a dorsal length of 35 mm. The aperture is not well displayed but is apparently transverse with a slight hyponomic sinus which is broad and shallow. The basal zone is well developed with its characteristic pitted pattern. The surface of the shell is unknown. One side of the specimen is missing and the width can only be inferred. Clearly the cross section is higher than wide, being estimated at 44 mm. at the base where the height is 50 mm., and 50 mm. at the base of the living chamber where the height is 60 mm. In cross section the greatest width lies ventrad of the center; the midventral region is obscurely angled, the dorsum strongly flattened.

Discussion.—This species is somewhat smaller than *T. magnum*, and the camerae of the adoral part of the phragmocone remain subequal in length, while they increase strikingly in depth when traced orad in a comparable portion of *T. magnum*. Further differences are found in the lobation of the sutures, for in *magnum* neither the lateral saddles nor the dorsal lobes are as strongly developed.

Holotype.—U. S. National Museum.

Occurrence.—From near the top of the section at the Pennsylvania Railway Station, Bay View, Michigan, labeled as Traverse group. Middle Devonian.

TUMIDOCERAS MAGNUM Flower, n. sp.
Plate 18, figure 1

The type is a nearly complete shell which has been crushed laterally, without, however, increasing the shell height. The conch, 19 mm. long, is faintly curved, with the venter slightly and uniformly convex over the lower three-fourths, the mature portion becoming slightly more convex. Dorsum faintly concave below, becoming straight, incomplete adorally, where it evidently becomes faintly convex. Sides diverging to the base of the living chamber, where they become strongly convex and then straighter, approaching each other toward the aperture. The phragmocone of 33 camerae has a ventral length of 170 mm.; the camerae increase gradually and uniformly in depth from 3 mm. to 7 mm.; the last camera is half the length of the penultimate one. The siphuncle is separated from the venter by more than its own diameter at the base of the specimen. Here the segments are slender, fusiform, with short strongly recurved but free septal necks, connecting rings forming barrel-shaped to fusiform segments not unlike those of *Dolorthoceras*, meeting the adapical septum with no area of adnation. No organic deposits are developed in the siphuncle. Farther orad, a section was ground to reveal the siphuncle. It shows that the segments are broadly nummuloidal, becoming wider than high, and strongly expanded within the camerae, but it fails to supply the proportions accurately. Here also organic deposits are absent.

The sutures develop the characteristic lateral saddles of the genus, which are most prominent dorsad of mid-height. The sutures slope apicad from the saddles, forming a broad shallow ventral lobe, transverse and obscure in the middle, and are essentially transverse over the dorsum.

The living chamber is gibbous, the greatest shell width occurring just above its base. Though the dorsum is missing the greatest height apparently occurs at about the same point. Fragments of the shell show that the surface bears low transverse markings, normal to the shell axis laterally and dorsally, but sloping apicad on the venter to form a shallow rounded broad hyponomic sinus. The aperture is obscure, but appears to be retained on the mid-ventral portion of the holotype.

Discussion.—This species, though represented by a somewhat distorted individual, is clearly distinct from *T. lentum*. The camerae increase more rapidly in depth over the

adoral part of the phragmocone. The suture pattern differs in that the lobes separated by the lateral saddles are deeper ventrally and shallower dorsally. The species is a larger one, and the adoral part of the phragmocone is more rapidly enlarging.

Holotype.—U. S. National Museum.

Occurrence.—Gravel Point formation, Middle Devonian, from west end of Petoskey Portland Cement Co. quarry about 2½ miles west-southwest of Petoskey, Michigan.

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EXPLANATION OF PLATE 20

FIGS. *1, 4*—*Muiroceras tuberculosum* Flower, n. sp., Holotype, ×1 (whitened), *1*, lateral view, *4*, ventral view, sutures and siphuncle strengthened by retouching. Middle Devonian, Long Island, Kasaan Bay, Alaska. U. S. National Museum. (p. 77)

2, 3—*Tumidoceras lentum* Flower, n. sp. Holotype, U. S. National Museum, ventral and lateral views ×1. Traverse group, Bay View, Mich. (p. 78)

Flower, New Devonian Nautiloid Genera

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 81–83, PL. 21, JANUARY, 1949

NEW FORAMINIFERA FROM NORTHWESTERN PERU

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International Petroleum Company, Talara, Peru

ABSTRACT—Two new genera, *Sporobuliminella* and *Sporobulimina*, are described from the Upper Cretaceous "*Clavulina*" shale and a new species of *Stichocassidulina* is described from the upper Eocene Talara formation of northwestern Peru.

During the course of recent micropaleontological work on well and field samples from northwestern Peru three new species of Foraminifera have been found which may be of value in correlations with the Cretaceous and Eocene sections of other countries. Two of these are new genera from the Upper Cretaceous and the other is a new species of *Stichocassidulina* from the upper Eocene. The latter genus has been found very useful in correlations on the La Brea-Parinas Estate and in making correlations with Ecuador and California.

Disposition of Type Specimens.—The specimens illustrated and described in this paper have been deposited in the type collections of the U. S. National Museum, Washington, D. C. Topotypes of the new species will be deposited in the collections of the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts.

Acknowledgements.—Thanks are due Helen Jeanne Plummer and Dr. J. A. Cushman for their valuable suggestions concerning the new genera and to Dr. E. P. DuBois for checking the manuscript.

Permission to publish this paper has been granted by the Chief Geologist and the Directors of the International Petroleum Company, Limited, to whom acknowledgement is made.

The illustrations of Foraminifera were drawn by Señor Manuel Alban.

Family BULIMINIDAE
Subfamily TURRILININAE
Genus SPOROBULIMINELLA Stone,
n. gen.
Genotype, *Sporobuliminella stainforthi*
Stone, n. sp.

Test a short tightly coiled spiral; four chambers in each whorl; spiral suture distinct; chambers inflated; sutures depressed; wall calcareous, perforate. Apertural area composed of two parts: the principal aperture is a low arched opening with a slight lip at the base of the last-formed chamber; the supplementary apertures are arranged in an almost circular pattern adjacent to the principal aperture and consist of numerous small circular openings.

This genus is similar to *Buliminella* in having a distinct spiral suture and four chambers in each whorl. The character of the principal aperture and the presence of numerous supplementary apertures, however, serves to readily distinguish it from that genus. *Sporobuliminella* is placed in the Buliminidae because of its similarity to *Buliminella*.

SPOROBULIMINELLA STAINFORTHI
Stone, n. sp.
Plate 21, figures 4–7

Test a short tightly coiled spiral; four chambers in each whorl; spiral suture distinct; chambers inflated; sutures depressed; wall calcareous, perforate. Initial end of microspheric form is pointed; chambers increasing rapidly in size as added; greatest diameter at the central portion of the test. Initial end of megalospheric form broadly rounded; test sub-spherical; chambers increasing rapidly in size as added; greatest diameter at the central portion of the test. Apertural area composed of two parts: the principal aperture is a low arched opening with a slight lip at the base of the last-formed chamber, the supplementary apertures are arranged in an almost circular pattern adjacent to the principal aperture and consist of numerous small circular openings outlined by low up-turned lips.

Dimensions of holotype (microspheric form): height 0.60 mm. diameter, 0.49 mm. Dimensions of area occupied by supplementary apertures: width, 0.26 mm., length, 0.32 mm. Diameter of circular supplemen-

tary apertural openings: .062 mm. Holotype and paratypes from the Upper Cretaceous "*Clavulina*" shale, sample No. S-49, on Las Cruces-Atascadera road in west bank of road cut 2.6 kilometers north of Las Cruces, Department of Piura, Peru.

Sporobuliminella stainforthi has been found to date only at its type locality about 100 feet above the base of the "*Clavulina*" shale. Here it is associated with a rich fauna consisting of *Lingulina taylorana* Cushman, *Siphogenerinoides clarki* Cushman and Campbell, *Neobulimina canadensis* Cushman and Wickenden and many other typical upper Cretaceous forms. It is very rare.

Family BULIMINIDAE
Subfamily BULIMININAE
Genus SPOROBULIMINA Stone
n. gen.
Genotype, *Sporobulimina perforata*
Stone, n. sp.

Test an elongate spiral; triserial; chambers inflated; spiral suture obsolete, other sutures somewhat depressed; wall calcareous, perforate. Apertural area composed of two parts: the principal aperture is a narrow elongate slit extending from the base of the last-formed chamber to about midway across the apertural face; supplementary apertures are numerous irregularly shaped openings arranged in a semicircular pattern adjacent to the principal aperture.

Sporobulimina is very similar to *Bulimina* from which it may be distinguished by the aperture and the presence of numerous supplementary apertures. It differs from *Sporobuliminella* in being triserial with an obsolete spiral suture, and having irregularly shaped supplementary apertures and an elongate slit principal aperture.

SPOROBULIMINA PERFORATA
Stone, n. sp.
Plate 21, figures 1–3

Test elongate, triserial; chambers inflated; sutures depressed; wall calcareous, perforate. Initial end of microspheric form pointed; chambers increasing rapidly in size as added; greatest diameter at central portion of test. Initial end of megalospheric form bluntly rounded, with a small sharp spine; chambers increasing slowly in size as added; greatest diameter is attained in the upper one-third of the test. Apertural area composed of two parts: the principal aperture is a narrow elongate slit extending from the base of the last-formed chamber to about midway across the apertural face; supplementary apertures are numerous irregularly shaped openings arranged in a semicircular pattern adjacent to the principal aperture. Both principal and supplementary apertures are rimmed by low up-turned lips.

Dimensions of holotype (megalospheric form): height, 0.62 mm., diameter, 0.39 mm. Dimensions of area occupied by supplementary apertures: length, 0.09 mm., width 0.06 mm. Diameter of circular supplementary apertures: 0.02 mm. Measurements of slit-like supplementary apertures: length, 0.04 mm., width, 0.01 mm. Holotype and paratypes from the Upper Cretaceous "*Clavulina*" shale, sample No. S-106, in south bank of Quebrada Chungo, 200 meters east of the Las Cruces-Pazul road.

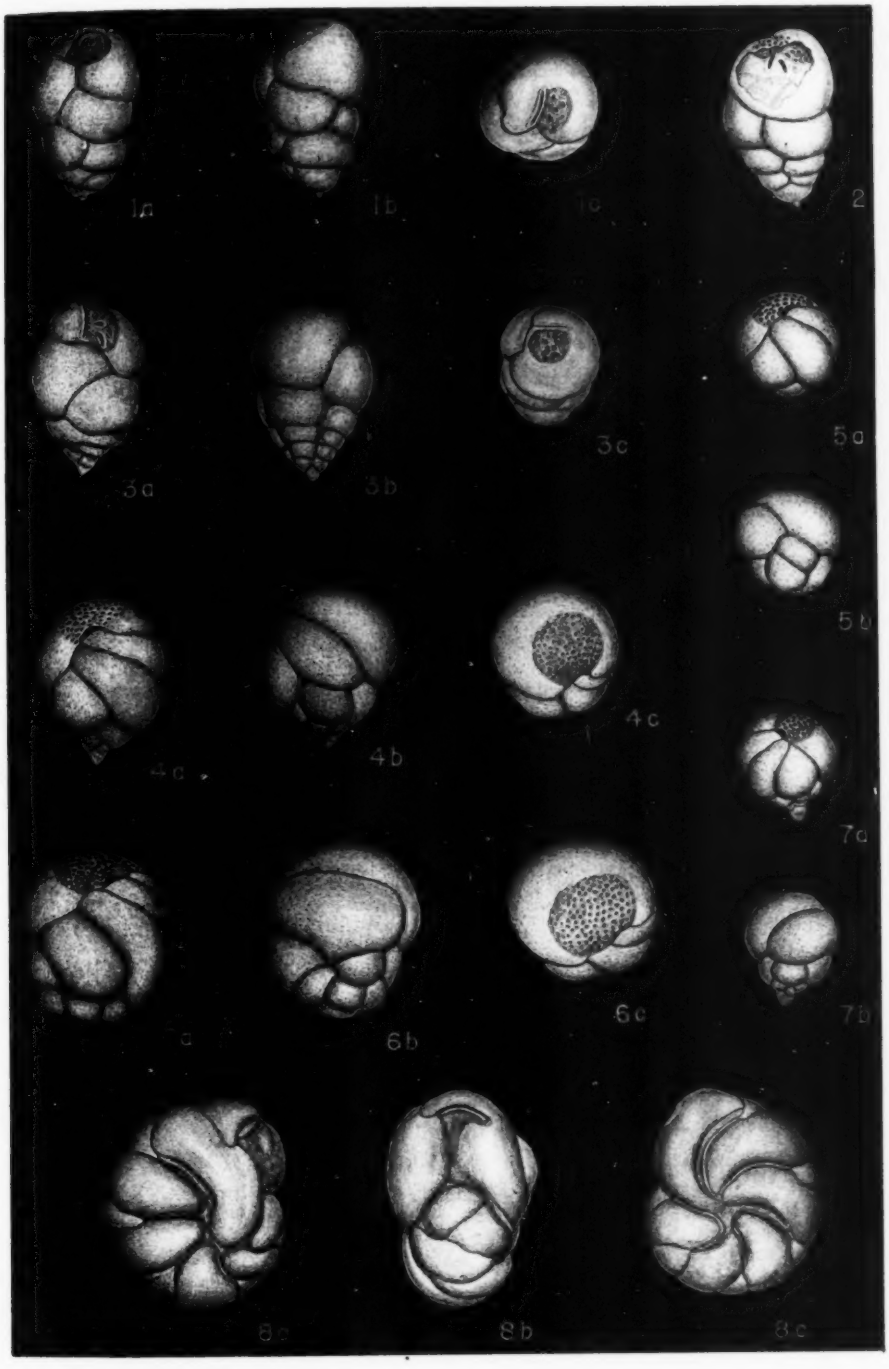
At its type locality *Sporobulimina perforata* is associated with *Siphogenerinoides ber-*

EXPLANATION OF PLATE 21

FIGS. *1–3*—*Sporobulimina perforata* Stone, n. sp., *1*, Holotype, ×36; *2–3*, paratypes, ×36. *1a*, Front view; *1b*, side view; *1c*, apertural view showing principal aperture and supplementary openings. *2*, side view of broken specimen showing apertures and foramina of the subjacent chamber. *3a*, front view of microspheric specimen; *3b*, back view of microspheric specimen; *3c*, apertural view of microspheric specimen. (p. 82)

4–7—*Sporobuliminella stainforthi* Stone, n. sp., *4*, Holotype, ×36; *5–7*, paratypes, ×36. *4a*, Front view; *4b*, back view; *4c*, apertural view showing principal aperture and numerous supplementary openings. *5a*, Front view of immature megalospheric form; *5b*, back view. *6a*, Front view of adult megalospheric form; *6b*, back view; *6c*, apertural view. *7a*, Front view of immature microspheric form; *7b*, back view. (p. 81)

8—*Stichocassidulina peruviana* Stone, n. sp., *8*, Holotype, ×36. *8a*, *8c*, Side views showing slit-like supplementary apertures along the sutures; *8b*, apertural view showing principal aperture. (p. 83)



Stone, New Foraminifera from Peru

mudezi Stone, *S. reticulata* Stone, *Bolivina explicata* Cushman and Hedberg and other typical Cretaceous forms. It is most abundant at its type locality 650 feet stratigraphically below the middle member of the "*Clavulina*" shale, but occurs rarely as much as 900 feet higher in the section.

Family CASSIDULINIDAE
Subfamily CASSIDULININAE
Genus STICHOCASSIDULINA Stone, 1946
STICHOCASSIDULINA PERUVIANA
Stone, n. sp.
Plate 21, figures 8a–c

Test close coiled, biserial, involute; chambers alternating on the two sides of the periphery, smooth, inflated; wall calcareous, finely perforate; sutures depressed. Apertures of two types: the principal aperture is a large roughly loop-shaped elongate opening in the apertural face of the last-formed chamber and almost entirely covered by a flat tooth-like plate; supplementary apertures are long narrow slit-like openings along the sutures of the test.

Dimensions of holotype height, 0.75 mm., breadth, 0.63 mm., thickness, 0.53 mm. The slit-like supplementary apertures often measure up to 0.25 mm. in length. Holotype from the upper Eocene Talara formation, Well No. 3565, depth 2040 feet, Square Mile 11-N-5, Malaca District, Department of Piura, northwestern Peru. In Well No. 3565 *Stichocassidulina peruviana* occurs 790 feet below the top of the Talara formation.

This species differs from *Stichocassidulina thalmanni* Stone by being more compressed, having narrower chambers and very long slit-like supplementary apertures along the sutures. In *S. thalmanni* the supplementary apertures are numerous small arcuate openings along the sutures.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 84–86, PL. 22, JANUARY, 1949

TWO CRETACEOUS ECHINOIDS FROM PERU

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ABSTRACT—*Orthopsis titicacana* and *Hemiaster* (*Macraster*) *cascajalensis* are described as new. The species from Brazil described by C. A. White in 1887 as *Cottaldia australis* is transferred to *Orthopsis*.

Several collections recently made by Norman D. Newell (1946) from near the base of the Ayavacas limestone member of the Moho formation west and northwest of Lake Titicaca in the Department of Puno, Peru, include two species of echinoids representing different genera. Although one, a *Tetragramma*, is not specifically identifiable and the other, an *Orthopsis*, is apparently undescribed, they throw some light on the correlation of the Ayavacas limestone, which is usually regarded as Aptian and Albian.

The geologic range of both *Tetragramma* and *Orthopsis*, as reported by Lambert and Thiery (1910, pp. 187, 199), is Jurassic and Cretaceous, but as both genera are the more abundant in the Cretaceous, their occurrence in Peru tends to corroborate the reference of the Ayavacas limestone member of the Moho formation to the Cretaceous. However, the genotype of *Tetragramma* comes from the Cenomanian and that of *Orthopsis* from the Senonian, and both genera attained their maximum proliferation in the Cenomanian. So it may be suspected that the Ayavacas limestone is somewhat younger than Aptian.

The species of *Tetragramma* is represented by five individuals from Newell's locality 104, north end of the bridge over Río Ilave at Ilave. None of them are well enough preserved for specific identification.

Orthopsis occurs at five localities, but apparently only one species is represented. It is most abundant at locality 159, a well about 4½ kilometers east-southeast of Ayavacas, from which 27 small individuals were obtained. These juveniles might be mistaken for a *Cottaldia* because of their nearly spherical shape and speciously imperforate tubercles, but their decoration is not that characteristic of *Cottaldia*, and a few tubercles retain the small perforated mamelon that is characteristic of *Orthopsis*,

The collection has been divided between the American Museum of Natural History at New York, which retains the holotype, and the United States National Museum at Washington.

One nearly complete *Hemiaster* and two siliceous crusts probably representing the same species, all the property of the Instituto Geologico del Perú, were placed in my hands for study by Dr. Newell. They were collected at Cerro Cascajal, near Lima, Peru, from greenish limestone referred to the Neocomian. Their resemblance to *Hemiaster elegans* Shumard (Cooke, 1946, p. 227), a species supposed to be restricted to deposits of late Albian age, casts doubt on this correlation.

ORTHOPSIS TITICACANA Cooke, n. sp.
Plate 22, figures 1–5

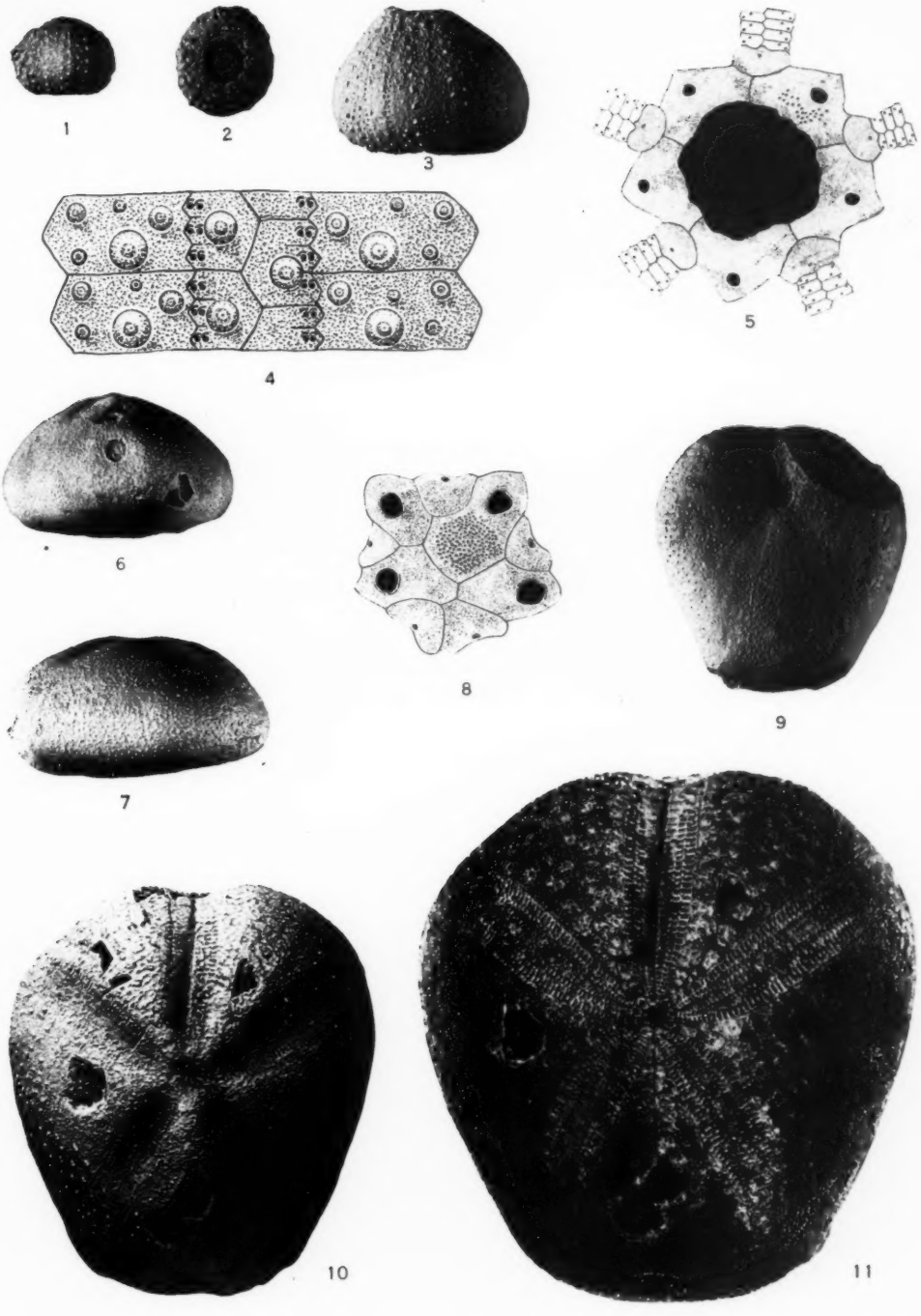
Subglobular, small, horizontal outline circular to subpentagonal. Apical system di-

EXPLANATION OF PLATE 22

FIGS. *1–5*—*Orthopsis titicacana* Cooke, n. sp. *1*, *2*, Side and bottom of type, AMNH, ×2; *3*, paratype, USNM, ×2; *4*, details of surface, enlarged; *5*, apical system, enlarged. (p. 84)

6–11—*Hemiaster* (*Macraster*) *cascajalensis* Cooke, n. sp., type. *6*, *7*, *9*, Posterior end, side, and bottom, ×1; *8*, apical system, enlarged; *10*, top, ×1.5; *11*, top, ×2, photographed under water. (p. 85)

Drawings by Elinor Stromberg; photographs by Nelson A. Shupe except *11*, which is by G. Arthur Cooper.



Cooke, Cretaceous Echinoids from Peru

cyclic, pentagonal. Ambulacral areas less than half as wide as the interambulacral; poriferous zones forming a straight line from ocular plates to peristome, three zygopores to each compound plate; interporiferous zones much wider than the zygopores, bearing one primary tubercle near the outer edge of each compound plate, the tubercles forming two continuous rows adjacent to the poriferous zones. Interambulacral areas wide, each bearing one primary tubercle near the middle of each plate and several smaller tubercles between it and the poriferous zones. Peristome small, less than half the total diameter, nearly circular, moderately notched. Periproct central, subcircular, rather large. Tubercles consisting of a large tumid boss surmounted by a very small perforated mamelon, which is commonly not preserved. Miliary areas scattered with granules. Spines slender, acicular.

Height 5.1 mm., diameter 7.0 mm., diameter of peristome 2.8 mm., diameter of periproct 1.0 mm. One individual from locality 19 measures 16 mm. in diameter; its peristome is 6.6 mm. across.

Comparisons.—*Orthopsis titicacana* appears to agree in all generic features with *Cidarites miliaris* d'Archiac, the genotype of *Orthopsis* Cotteau, 1863, as figured by Cotteau (1864, p. 558, pl. 1131). In decoration, however, it more closely resembles *Orthopsis ovata* (Coquand) from the Cenomanian of Algeria as figured by Cotteau (1864, pl. 1132), but it is very much smaller and none of its ocular plates touch the periproct.

The only other South American *Orthopsis* to which I have a reference is *Orthopsis australis* (White) (1887, p. 251, pl. 27, figs. 13, 14), which was described as a *Cottaldia* but which has plainly perforate tubercles. (Lambert and Thiery, 1910, p. 201, refer it to *Hebertia*.) This Brazilian species is much more depressed than the Peruvian *O. titicacana*.

Two species of *Orthopsis* have been described from the Washita group of Texas, *O. occidentalis* Cragin and *O. charltoni* (Cragin) (Cooke, 1946, p. 214, pl. 31, figs. 6, 7). Both of these species are more depressed than *O. titicacana* and *O. occidentalis* has a much smaller peristome. *O. charltoni* occurs in the Main Street limestone, which is probably of early Cenomanian age.

Occurrence.—Newell's locality 159, about 4½ km. east-southeast of Ayavacas, Department of Puno, Peru; 800 meters southeast of the summit of Cerro Tucurgachí, open well at north side of Ayavacas-Urcunimuni road (type and 26 other individuals). Localities 17 and 19, 500 meters southwest of camp office, Pirín, Department of Puno (two individuals, each embedded in hard limestone). Locality 135, Cerro Conchacaní, highway cut on road to Moquegua, 7 km. southeast of Puno (one individual embedded in limestone). Locality 13, 400 meters west of Aguallane School, near Pirín, Department of Puno (one slab of limestone containing several poorly preserved echinoids probably representing this species).

Geologic horizon.—Lower 2 meters of Ayavacas limestone member of the Moho formation, probably of Cretaceous age.

Types.—Holotype, American Museum of Natural History; paratypes, United States National Museum.

Hemiaster (Macraster) cascajalensis Cooke, n. sp.

Plate 22, figures 6–11

Test cordate, moderately high, gently rounded below, truncated behind. Apical system central; ocular plates large, lunate, perforated, the posterior plate wanting; right anterior and left posterior plates touching all the other genital plates, the other two genital plates separated by the madreporite, which is almost central. Ambulacral areas petaliferous, petals open at the distal end, the anterior pair longer than the posterior pair and extending almost to the margin; paired petals in shallow depressions, anterior unpaired petal in a deeper groove, which extends to the peristome, anterior paired petals diverging at an angle approximating 108°, the posterior about 64°. Poriferous zones of anterior petal like the others, the zygopores consisting of a long outer slot and an inner slot about half as long as the outer and in line with it. Zygopores beyond the petals much smaller and farther apart, the pores commonly oval and forming an obtuse angle with each other. Peristome subpentagonal, rather large, the distance from its center to the anterior part of the ambitus less than one-third of the total length of the test. Periproct smaller

than the peristome, oval, higher than wide, situated well up on the posterior truncation, plainly visible from above. Tubercles rather far apart except along the ambitus, where they are more numerous. No bare fasciole discernible.

Length 37.3 mm., width 34.6 mm., height 20.1 mm.

Comparisons.—*Hemiaster cascajalensis* most closely resembles *H. elegans washitae* (Lambert) (Cooke, 1946, p. 229, pl. 33, figs. 1–4) from the Comanche Washita group of Texas, from which it differs in its slightly shorter petals, less angular outline, and less steeply sloping posterior truncation. Moreover, the two slot-shaped pores comprising each zygopore of its anterior petal are aligned, whereas those of *H. washitae* are slightly inclined with respect to each other. In general appearance it resembles *H. whitei* (Clark) (Cooke, 1946, p. 224, pl. 32, figs. 16, 17), whose outline is more rounded, posterior truncation steeper, and whose anterior zygopores are not linear but consist of sharply inclined ovate pores separated by a granule.

Occurrence.—Cerro Cascajal, near Lima, Peru.

Geologic horizon.—In greenish limestone referred to the Neocomian. However, its resemblance to *Hemiaster elegans washitae*, a species supposed to be restricted to beds of upper Albian age, casts doubt on this correlation.

Type.—Instituto Geológico del Perú. Replicas in the United States National Museum and the American Museum of Natural History.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 87–94, PLS. 23, 24, JANUARY 1949

NEW TERTIARY MOLLUSCA FROM JAPAN

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ABSTRACT—Described as new are: *Nucula kokozuraensis, Nuculana karihaensis, Glycymeris nakosoensis, Anadara (Anadara) kakehataensis, Anadara (Anadara) kurosedaniensis, Barbatia (Barbatia) uetsukiensis, Mytilus ogawaensis, Volsella yokoyamai, Periploma pulchellum, Trapezium jobanicum, Lucinoma otukai, Codakia kitamurai, Spisula polynyma nagakoensis, Calliostoma (Tristichotrochus?) batoense, Neia schencki,* and *Shichiheia etchuensis. Neia* and *Shichiheia* are proposed as new genera. *Neia* is related to both *Telescopium* and *Vicarya,* distinguished from the former by the non-denticulated, stouter, and straighter columella, and from the latter by the non-sinuated outer lip lacking callosity, and by the *Telescopium*-like sculpture. *Shichiheia* is close to *Phalium* but is distinguished by lack of any notch anteriorly in the aperture, by the thin outer lip, the tuberculated and granulated sculpture, and the stouter, less recurved columella.

In compiling a check list of the Tertiary marine Mollusca of Japan it was found that many original specimens had been destroyed, lost, or misplaced. Comparisons with the originals being impossible, new collections from previously-cited localities were undertaken to obtain topotypes. At several of these localities new species have come to light, especially at some rather isolated localities of Oligocene and Miocene age. The new forms are described in this paper.

The writers take pleasure in acknowledging their appreciation to: Lieutenant-Colonel Hubert G. Schenck, Chief of the Natural Resources Section, Supreme Command for the Allied Powers and Professor of Geology at Stanford University, California, under whose encouragement the present work was done; Professor Shoshiro Hanzawa and Mr. Kimiji Kimagai of the Institute of Geology and Palaeontology, Tohoku University, Sendai, for help in completion of the work.

SYSTEMATIC DESCRIPTIONS

Family NUCULIDAE
Genus NUCULA Lamarck, 1799
NUCULA KOKOZURAENSIS Hatai and Nisiyama, n. sp.
Plate 23, figures 1–5

Shell moderate in size and thickness, roundly trigonal, dorsal margin slightly convex, anteriorly rather narrowly rounded, ventral margin arcuate, posterior convex outward; beaks small, rather sharply inturned; lunule not defined, lanceolate; escutcheonal region incised, with weak ridges; surface with irregularly spaced concentric threads which bifurcate; inner margin smooth. Height of holotype, 19.0 mm., thickness of intact shells, 13.2 mm.

Occurrence.—A small cliff in front of the grocery store at the northern entrance of Kokozura, Nakoso-Machi, Ishiki-Gun, Fukushima-Ken. Kokozura formation, Miocene.

Repository.—IGPS Cat. No. 72507 (holotype). IGPS = Institute of Geology and Palaeontology, Tohoku University, Sendai).

Remarks.—This species is distinguished from *Nucula dautzenbergi* Prashad (1932, pl. 1, figs. 13–16), a Recent shell from the Samau Strait, by the more outwardly produced dorsal margin, and by the less pronounced posterior margin.

Family NUCULANIDAE
Genus NUCULANA Link, 1807
NUCULANA (NUCULANA) KARIHAENSIS Hatai and Nisiyama, n. sp.
Plate 24, figures 3, 4

Shell broadly trigonal in outline, inequilateral, throughout moderately convex, posterior end bluntly angular; base broadly rounded; dorsal margin convex in front, concave behind; surface with fine concentric lines, as broad as the interspaces; beaks small, inturned and almost touching each other. Length of holotype 21.5 mm., height 12.6 mm., diameter of intact shells 7.7 mm.

Occurrence.—Bridge leading to Takayanagi, Ishiguro-Mura, Kariha-Gun, Niigata-Ken. Ishiguro formation, Miocene.

Repository.—IGPS Cat. No. 72633.

Remarks.—This species is distinguished from *Nuculana magarikawaensis* Nomura and Zinbo (1937, pl. 12 ,figs. 3, 4), a Miocene species from Yamagata-Ken, by the larger size, less convex posterior dorsal margin, and less trigonal outline of the shell.

Family GLYCYMERIDAE
Genus GLYCYMERIS Da Costa, 1778
GLYCYMERIS NAKOSOENSIS Hatai and Nisiyama, n. sp.
Plate 23, figures 15, 16

Shell rather heavy, inflated, suborbicular in outline; inner margin with strong crenulations narrower than the interspaces; hinge-line moderately arcuate, with strong converging teeth, nine at sides and about eight in the middle, the former converging, the latter vertical; about four incremental lines on narrow area; beak small, pointed; umbonal region inflated; surface with rather crude concentric lines; radial sculpture indistinct; muscular impressions rather strong. Length of holotype 24.0 mm., width 23.5 mm., depth of a right valve 7.0 mm.

Occurrence.—A small cliff in front of the dormitory of the Nippon Coal-Mining Company, Nakoso-Machi, Ishiki-Gun, Fukushima-Ken. Iwaki formation, Oligocene.

Repository.—IGPS Cat. No. 72502.

Remarks.—More or less related to this species are *Glycymeris vestitoides* Nomura (1935, pl. 5, figs. 4–7), *Glycymeris oinouyei* Nomura (1935, pl. 3, fig. 1), and young specimens of *Glycymeris cisshuensis* Makiyama (1926, pl. 13, figs. 2, 3). However, the convexity of the valves, size of the adult shell and details of the outline serve to distinguish the present species from those mentioned. There are no species of *Glycymeris* from the Oligocene or Eocene formations of Japan with which the present one can be compared.

Family ARCIDAE
Genus ANADARA Gray, 1847
ANADARA (ANADARA) KAKEHATAENSIS Hatai and Nisiyama, n. sp.
Plate 23, figures 8–10

Shell heavy, moderate in size, quadrate, posterior side straight; equivalve, inequilateral, ventral border squarely rounded; umbonal region swollen, beak rather strongly incurved anteriorly; posterior slope more defined than anterior and diverging from the lateral slope at the 17th–19th radial riblet; area broad, arcuately trigonal in profile; surface with radial riblets and concentric lines, the former about 25 in number squarely rounded, weakly granulated, about equal to flattened interspaces in width; radial riblets somewhat corrugated ventrally by the crossing of the concentric lines. Length of holotype 49.5 mm., height 44.8 mm., thickness of intact shells 46.0 mm.

Occurrence.—West cliff, about 50 meters south of the bridge at Kakehata, Unohana-Mura, Nei-Gun, Toyama-Ken. Susahara formation, Miocene.

Repository.—IGPS Cat. No. 72510.

Remarks.—*Anadara daitokudoensis* Makiyama (1926, pl. 12, figs. 10, 14, 15) from the Miocene of Korea and of several Miocene formations in Japan is distinguished from the present species by the radial ribs and posterior slope. The posterior slope is

EXPLANATION OF PLATE 23

FIGS. *1–5*—*Nucula kokozuraensis* Hatai and Nisiyama, n. sp. *1*, Left valve of holotype. *2*, Umbonal view of holotype. *3*, Dorsal view of holotype. *4*, left valve of paratype. *5*, Interior of paratype. ×1. (p. 87)

6, 7—*Barbatia* (*Barbatia*) *uetsukiensis* Hatai and Nisiyama, n. sp., ×2. (p. 89)

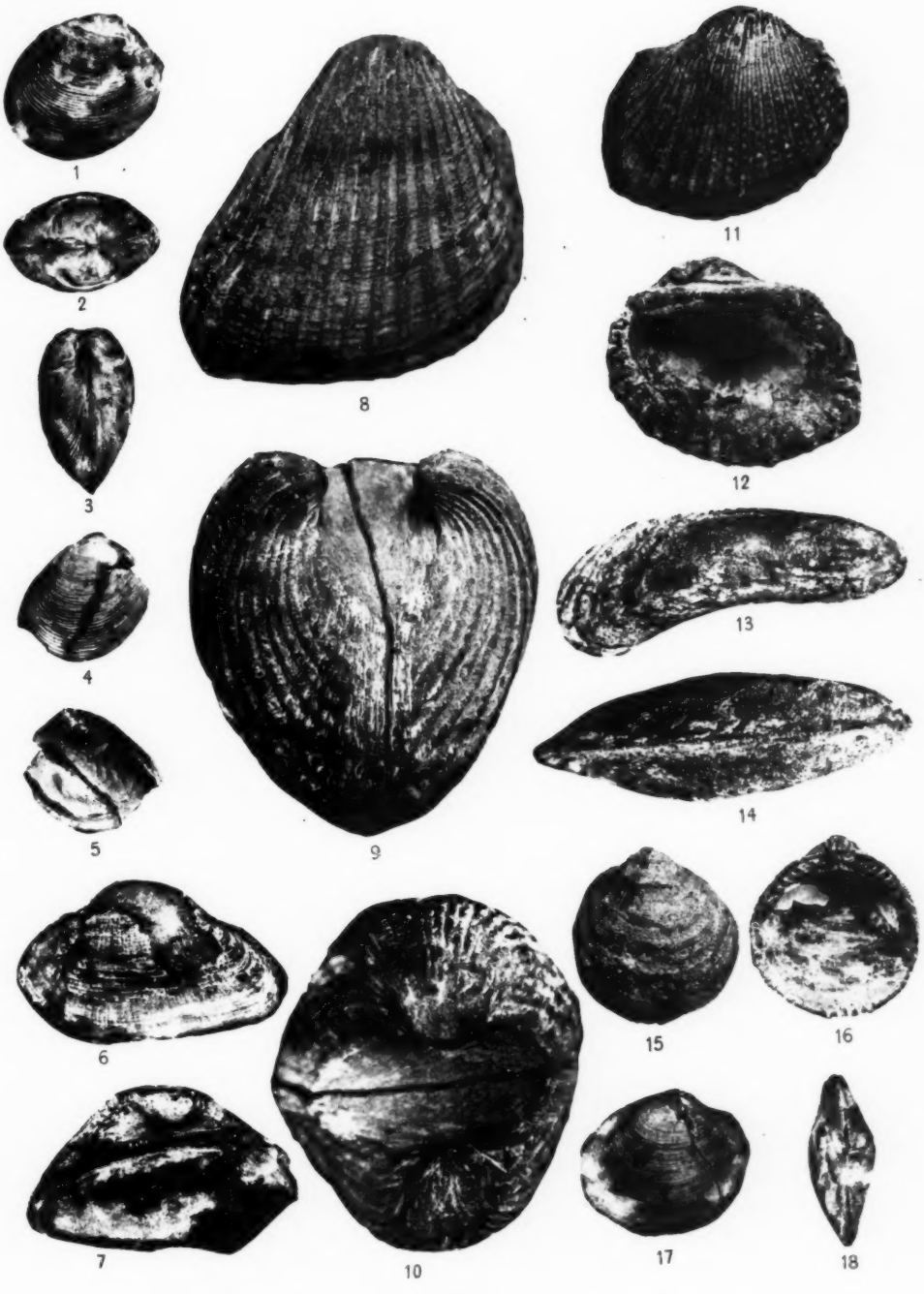
8–10—*Anadara* (*Anadara*) *kakehataensis* Hatai and Nisiyama, n. sp. *8*, Right valve of holotype; *9*, Posterior view of beaks and area of holotype; *10*, Umbonal view of holotype. ×1. (p. 88)

11, 12—*Anadara* (*Anadara*) *kurosedaniensis* Hatai and Nisiyama, n. sp., ×2. (p. 89)

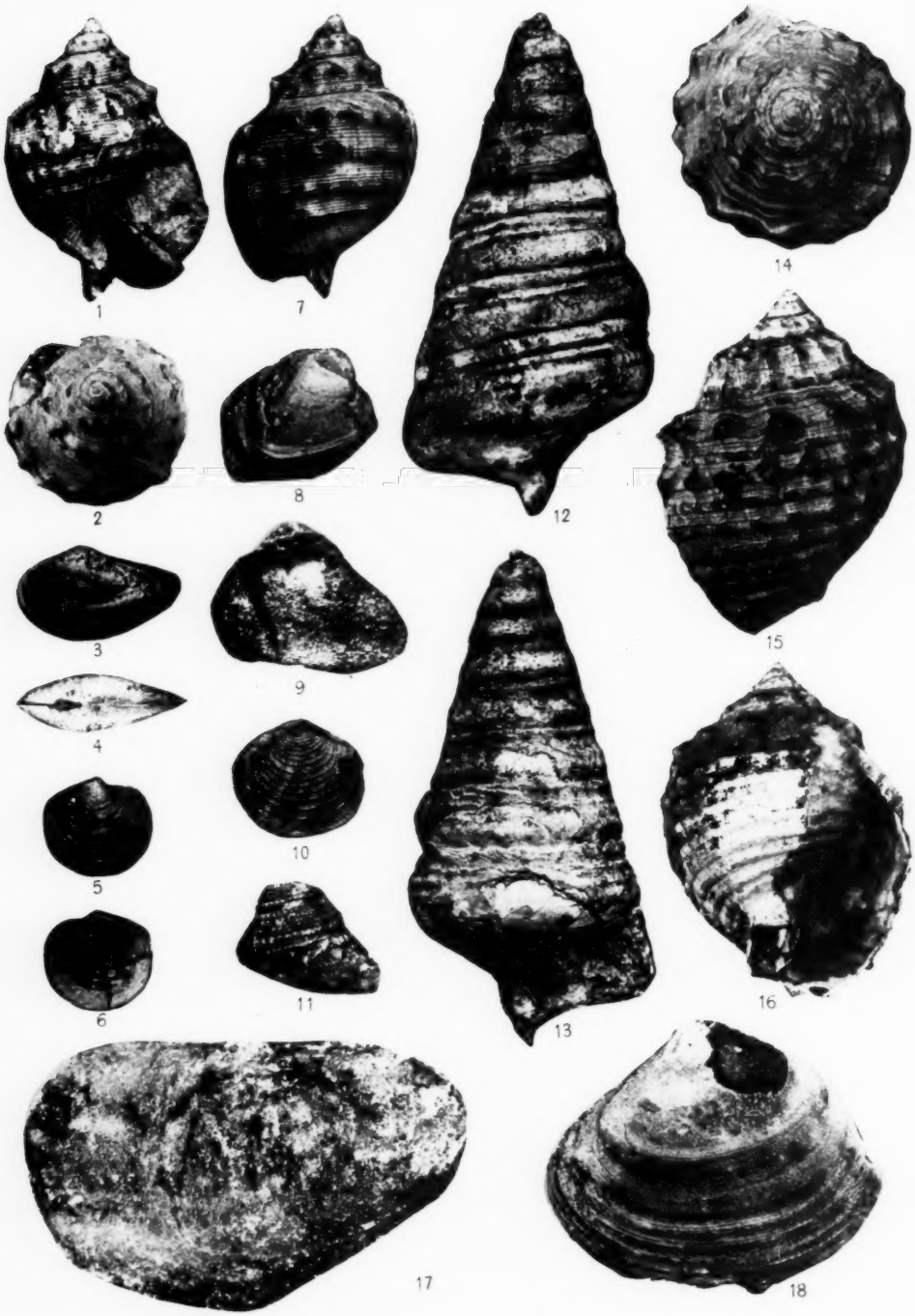
13, 14—*Volsella yokoyamai* Hatai and Nisiyama, n. sp. *13*, Right valve; *14*, Dorsal view of the holotype. ×1. (p. 90)

15, 16—*Glycymeris nakosoensis* Hatai and Nisiyama, n. sp., ×1. (p. 88)

17, 18—*Periploma pulchellum* Hatai and Nisiyama, n. sp., ×1. (p. 90)



Hatai and Nisiyama, New Japanese Tertiary Mollusca



Hatai and Nisiyama, New Japanese Tertiary Mollusca

stronger and the ribs more outstanding in *A. kakehataensis* compared with *A. daitokudoensis*.

ANADARA (ANADARA) KUROSEDANIENSIS
Hatai and Nisiyama, n. sp.
Plate 23, figures 11, 12

Small, quadrate in outline; posterior side straighter than the rounded anterior; ventral margin broadly rounded, postero-ventral and postero-dorsal corners sharply angulate; antero-ventral and antero-dorsal margins rounded; umbonal region flatly swollen, beaks rather sharply incurved; area narrow, widely trigonal, incised with one deep line; surface with 24 radial riblets, of which the anterior 11 are granulated, squarely elevated, narrower than the interspaces, which are flat-bottomed; posterior 14 radial riblets smooth; inner margin strongly crenulate; muscular impressions roundly quadrate, incised; about 34 hinge-teeth. Length of holotype 17.2 mm., height 14.0 mm., thickness of a right valve 6.0 mm.

Occurrence.—West cliff, about 50 meters south of the bridge at Kakehata, Unohana-Mura, Nei-Gun, Toyama-Ken. Susahara formation, Miocene.

Repository.—IGPS Cat. No. 72511.

Remarks.—Since only the anterior half of the shell has granular sculpture, this species can easily be distinguished from other species of *Anadara* from Japan.

Genus BARBATIA Gray, 1842
BARBATIA (BARBATIA) UETSUKIENSIS
Hatai and Nisiyama, n. sp.
Plate 23, figures 6, 7

Shell small, narrowly quadrate in outline, nearly twice longer than high; anteriorly rounded, posteriorly acute; antero-ventral margin broadly rounded, postero-ventral corner acutely rounded; hinge line with ventrally convergent teeth becoming very small at center; ligamental area narrow, its sculpture indistinct, inner shell margin smooth; umbonal region swollen; beak small and pointed; surface with radial and concentric sculpture; radials thread-like, irregular, about twice the interspaces in width, hardly elevated, narrow on top, numbering 10–11 per 5 millimeters at ventral margin, more crowded on anterior ventral half of shell, weakest on anterior and posterior margins; concentric lines fine, crossing the radial riblets; not foliate or corrugate at ventral margin. Height of holotype 11.0 mm., length 19.0 mm., thickness of a left valve 5.5 mm.

Occurrence.—Road-side cutting about 100 meters northeast of the shrine at Dainichi-Saka, Uetsuki-Mura, Katsuta-Gun, Okayama-Ken. Uetsuki formation, Miocene.

Repository.—IGPS Cat. No. 72522 (holotype), 72525 (paratype).

Remarks.—*Barbatia stearnsi* Pilsbry (1895, pl. 3, figs. 8, 9, 10) resembles the present species, but the larger shell, less decussated sculpture and the more prominent umbonal region distinguishes the present one from that species. *Barbatia symmetrica* (Reeve) (Kuroda, 1930, fig. 33) has a shorter shell with stronger radial sculpture as compared with the present species.

Family MYTILIDAE
Genus MYTILUS Linné, 1758
MYTILUS OGAWAENSIS Hatai
and Nisiyama, n. sp.
Plate 24, figure 17

Shell moderate in size and thickness, rather compressed; almost straight in front;

EXPLANATION OF PLATE 24

FIGS. *1, 2, 7*—*Shichiheia etchuensis* Hatai and Nisiyama, n. sp. *1*, front; *7*, back; *2*, apical views of the holotype, ×1. (p. 93)
3, 4—*Nuculana* (*Nuculana*) *karihaensis* Hatai and Nisiyama, n. sp., ×1. (p. 87)
5, 6—*Codakia kitamurai* Hatai and Nisiyama, n. sp., ×1. (p. 91)
8, 9—*Trapezium jobanicum* Hatai and Nisiyama, n. sp., ×1. (p. 90)
10—*Lucinoma otukai* Hatai and Nisiyama, n. sp., ×1. (p. 91)
11—*Calliostoma* (*Tristichotrochus?*) *batoense* Hatai and Nisiyama, n. sp., ×1. (p. 92)
12–13—*Neia schencki* Hatai and Nisiyama, n. gen., n. sp., ×1. (p. 92)
14–16—*Shichiheia yokoyamai* (Nomura and Hatai). For comparison with figs. *1, 2, 7*, ×1. (p. 93)
17—*Mytilus ogawaensis* Hatai and Nisiyama, n. sp., ×1. (p. 89)
18—*Spisula polynyma nagakoensis* Hatai and Nisiyama, n. subsp., ×1. (p. 92)

rather acutely arched dorsally; posteriorly broadly rounded; anteriorly bluntly pointed; surface with crude concentric sculpture. Length of holotype 66.5 mm., width 42.3 mm., approximate thickness of an isolated valve 8.0 mm.

Occurrence.—From a stream exposure slightly west of Ogawa, Kawabe-Mura, Ishiki-Gun, Fukushima-Ken. Iwaki formation, Oligocene.

Repository.—IGPS Cat. No. 72503 (holotype), 72512 (paratype).

Remarks.—*Mytilus grayanus* Dunker (Lischke, 1896, pl. 18, figs. 7, 8), a Recent shell from the seas around Japan, is similar to the new species, but has a shorter shell and is more strongly arched along the dorsal border and has a more rounded posterior side.

The paratype measures 82 mm. in length, 23 mm. in thickness of intact valves and about 50 mm. in width, if it were not fractured.

Genus VOLSELLA Scopoli, 1777
VOLSELLA YOKOYAMAI Hatai and Nisiyama, n. sp.
Plate 23, figures 13, 14

Shell narrowly rounded; both anterior and posterior sides bluntly rounded; ventral side broadly concave; dorsal nearly straight, only slightly arched; umbonal region blunt; faint defined ridge extending from umbonal region to postero-ventral border; surface with crude concentric lines, becoming corrugated at margins. Length of holotype 50 mm., thickness of intact valves 17.0 mm., height 16.0 mm.

Occurrence.—Near the Mimatsu Colliery, Ogawa, Kawabe-Mura, Ishiki-Gun, Fukushima-Ken. Iwaki formation, Oligocene.

Repository.—IGPS Cat. No. 72504.

Remarks.—The slightly arched dorsal border, cylindrical narrow shell and blunt umbo serve to distinguish this species from the well known *Volsella modiolus* (Linné) (Kinoshita and Isahaya, 1934, pl. 10, fig. 71).

Family LATERNULIDAE
Genus PERIPLOMA Schumacher, 1817
PERIPLOMA PULCHELLUM Hatai and Nisiyama, n. sp.
Plate 23, figures 17, 18

Shell small, thin, rather long, more or less elongated; inequivalve; right valve deeper and larger than left; anterior part of shell longer and larger than posterior; anterior and posterior borders rounded, the latter more sharply than the former; antero-dorsal margin nearly straight; postero-dorsal excavated; beaks rather large, opisthogyrous, situated posterior to middle of shell length; narrow slit under beaks rather long and prominent; sculpture of concentric fine undulations disappearing toward ventral margin; chondrophore buttress thin and long; both valves rather thick, convex in the middle and depressed near posterior end, the depression extending from beaks to posterior end of shell. Length of holotype 27.0 mm., height 22.0 mm., thickness 10.0 mm.

Occurrence.—A small cliff in front of the grocery store at the northern entrance to Kokozura, Nakoso-Machi, Ishiki-Gun, Fukushima-Ken. Kokozura formation, Miocene.

Repository.—IGPS Cat. No. 72507.

Remarks.—The higher and more angulated shell distinguishes this species from *Periploma owasense* Suzuki (Suzuki in Suzuki and Ito, 1946, pp. 20–21), from the Yukuno-Ura Miocene in Wakayama-Ken. *Periploma besshoense* (Yokoyama) (1924, pl. 2, figs. 1–5) has a larger, more equilateral and thinner shell compared with the present species, which is smaller.

There are only three species of *Periploma* recorded from the Tertiary formations of Japan, viz., *P. besshoense* (Yokoyama) of the Oligocene; *P. owasense* Suzuki and *P. yokoyamai* Makiyama (1934, p. 153), both of the Miocene; the present species is the fourth. All, so far as known at present, are restricted in range from the Oligocene to the lower or middle Miocene.

Family LIBITINIDAE
Genus TRAPEZIUM Mühlfeld, 1811
TRAPEZIUM JOBANICUM Hatai and Nisiyama, n. sp.
Plate 24, figures 8, 9

Shell moderately thick, quadrate; anterior side bluntly rounded, ventral margin nearly straight; antero-ventral margin bluntly rounded; posterior side squarely rounded; dorsal border nearly parallel to ventral; umbonal region swollen, beak rather strongly incurved; posterior one-third of

shell rounded and sharply inclined; surface with crude concentric lines on posterior one-third of shell; hinge-teeth characteristic of the genus. Length of the holotype 23.5 mm., height 17.0 mm., depth of a right valve 6.0 mm.

Occurrence.—A small cliff in front of the dormitory of the Nippon Coal-Mining Company, Nakoso-Machi, Ishiki-Gun, Fukushima-Ken. Iwaki formation, Oligocene.

Repository.—IGPS Cat. No. 72506.

Remarks.—The characteristic outline of the shell and features of the umbonal region serve to distinguish this species from the recorded species of the genus from Japan.

Family LUCINIDAE
Genus LUCINOMA Dall, 1901
LUCINOMA OTUKAI Hatai and Nisiyama, n. sp.
Plate 24, figure 10

Shell suborbicular, wider than high, much compressed; dorsal borders straight, anterior and posterior sides of the shell expanded, ventral border broadly rounded; beak small, pointed; umbonal region not swollen; surface with rather uniformly spaced periodic concentric lamellae and very weak intercalary striae. Height of the holotype 17.0 mm., width 19.5 mm.

Occurrence.—Fukuda, Sekimoto-Mura, Taga-Gun, Ibaragi-Ken. Kamenoo formation, Miocene.

Repository.—IGPS Cat. No. 72501.

Remarks.—This species is characterized by its antero-posterior expanded shell, the compressed nature of the valves, periodic concentric lamellae with intervening fine striae, and the arched antero- and postero-dorsal borders. A large size specimen attains 45 mm. in height and 56 mm. in width. The dentition is normal in all of the examined specimens.

This is a characteristic species in the Kamenoo formation of the Jô-Ban coal-field and seems to be a good horizon marker.

This species is distinguished from *Lucinoma annulata* (Reeve) from the Pleistocene of San Pedro, Los Angeles County, California by the much more compressed valves, more distinct striae between the concentric lamellae, the less defined beak and more arched antero- and postero-dorsal borders. *Lucinoma acutilineata* (Conrad) from the Miocene (Temblor) of Wagonwheel Mountain, Kern County, California, has a straighter antero-dorsal margin and a higher shell compared with the present new species.

The specific name is given in honor of Dr. Yanosuke Otuka of the Tokyo University, in recognition of his work on the Tertiary formations of Japan.

Genus CODAKIA Scopoli, 1777
CODAKIA KITAMURAI Hatai and Nisiyama, n. sp.
Plate 24, figures 5, 6

Shell moderately thick, orbicular, equivalve, moderately inflated; dorsal borders shouldered, nearly straight; other sides equally rounded; surface with fine, sharply raised, narrow concentric lamellae, narrower than the interspaces, uniformly distributed over the surface; corrugated at dorsal extremities, interspaces finely pustulated, giving the shell a reticulate appearance, particularly clear under magnification; umbonal region moderately swollen; beak small, sharply incurved; lunule deeply seated, heart-shaped, smooth on bottom; ligamental area narrowly elongate, inner surface with distinct radial striae. Height of holotype 14.0 mm., width 15.6 mm., thickness of intact shell 7.8 mm.

Occurrence.—Shukunohora, Hiyoshi-Mura, Toki-Gun, Gifu-Ken. Hiyoshi formation, Miocene.

Repository.—IGPS Cat. No. 72526 (holotype), 72527 (paratype).

Remarks.—The dimensions (in mm.) of some paratype specimens are as follows:

	Right valve	Left valve	Left valve	Intact valve	Intact valve	Intact valve
Height of shell	21.0	fract.	17.0	23.2	22.0	13.2
Width of shell	fract.	23.5	19.0	23.5	fract.	23.5
Thickness of shell	6.0	6.0	5.5	13.5	12.0	11.0

The fine pustulation in the interspaces, which make the surface appear reticulate under magnification, is obvious in all of the specimens. In two isolated valves, a right and left, the anterior adductor or its prolongation was found to be elongated (ca. 4.5 mm.) parallel to the pallial-line, rather deeply incised, and the inner shell surface rather thickly deposited with additional calcareous material. Whether this feature is an abnormality or whether it suggests specific separation can only be settled after more material has been found and studied.

The uniform concentric lamellae and fine reticulate sculpture distinguishes *C. kitamurai* from the other known species of the genus from Japan.

The specific name is given in honor of Mr. Nobu Kitamura, graduate of our Institute and now geologist of the Geological Survey of Japan, in recognition of his work on the Tertiary formations in Gifu-Ken.

Family MACTRIDAE
Genus SPISULA Gray, 1837
SPISULA POLYNYMA NAGAKOENSIS
Hatai and Nisiyama, n. subsp.
Plate 24, figure 18

Shell rather thick, moderate in size, compressed, roundly trigonal in outline; ventral border broadly rounded, antero-dorsal margin steeply sloping; anterior side narrowly rounded; postero-dorsal border steeply sloping; surface with fine concentric lines; umbo moderately inflated, small, curved and pointed. Length of holotype 47.5 mm., height 36.5 mm.

Occurrence.—Small exposure in drainage west of Nagako, Nishiki-Mura, Ishiki-Gun, Fukushima-Ken. Asagai formation, Oligocene.

Repository.—IGPS Cat. No. 72506.

Remarks.—This subspecies resembles *Mactra* (*Mactromeris*) *polynyma voyi* (Gabb) (as figured by Kinoshita and Isahaya, 1934, pl. 14, fig. 102) from the seas adjacent to Hokkaido, but not the holotype of *Spisula polynyma voyi* (Gabb) (Stewart, 1930, pl. 15, fig. 6). However, compared with the former, the present species has a shorter antero-dorsal border and the umbonal region is more characteristically incurved.

Family TROCHIDAE
Genus CALLIOSTOMA Swainson, 1840
CALLIOSTOMA (TRISTICHOTROCHUS?)
BATOENSE Hatai and Nisiyama, n. sp.
Plate 24, figure 11

Two and one-half adult whorls preserved in holotype. Test thin; whorls conic, flat, separated by distinct sutures; sculpture of beaded cords becoming less distinct on base; each whorl provided with four beaded cords, the lowest strongest and most prominent, the uppermost with long narrow pillars as if formed by fusion of the double beads; beads nearly equal to or even slightly narrower than their interspaces; one interstitial thread occurs between second and third primary; base marked with five weakly beaded, slightly elevated spiral threads and one strong beaded spiral which defines basal part from other whorls; interspaces of basal threads much wider than the others and with no trace of interstitial threads. Height of second whorl of holotype 6.5 mm., diameter of same 14.3 mm., maximum diameter of body-whorl 18.0 mm.

Occurrence.—North cliff of the Mumo-Gawa, 150 meters east of the bridge southwest of Batô-Machi, Nasu-Gun, Tochigi-Ken. Karasuyama formation, Miocene.

Repository.—IGPS Cat. No. 72515.

Remarks.—Although only about three adult whorls are preserved, the characteristic sculpture distinguishes this species from the well-known *Calliostoma aculeatum* Sowerby (Ikebe, 1942, pl. 27, figs. 1, 2, 3), from the seas of Japan.

Family POTAMIDIDAE
Genus NEIA Hatai and Nisiyama, n. gen.

Test large, heavy, more than eight and one-half broadly conical whorls; sculpture consisting of spiral ribbon-like cords and sinuous growth lines; columella stout, straight, short without denticulations or folds.

Genotype: *Neia schencki* Hatai and Nisiyama, n. sp.

NEIA SCHENCKI Hatai and
Nisiyama, n. sp.
Plate 24, figures 12, 13

Test large, thick, heavy; eight and one-half whorls preserved in holotype; broadly

conical, rapidly enlarging; *Telescopium*-like; whorls with only spiral sculpture and sinuous growth lines; spirals consist of one very broad ribbon-like gently rounded cord at the lowest of each whorl, with two narrower ones above and a somewhat broader one at the uppermost of each whorl, all with much narrower interspaces; each whorl separated from the preceding by indistinct sutures; base smooth except for strong sinuous growth lines; columella stout, straight, short, without denticulations or folds. Height of holotype 70.6 mm., diameter 33.6 mm., height of second whorl 9.5 mm.

Occurrence.—West cliff about 50 meters south of the bridge at Kakehata, Unohana-Mura, Nei-Gun, Toyama-Ken. Susahara formation, Miocene.

Repository.—IGPS Cat. No. 72517.

Remarks.—Although the aperture is fractured it seems to have been roundly quadrate in outline.

The present new species can be distinguished from the well-known *Telescopium* Montfort (Thiele, 1935, p. 207) with which it shows affinity, particularly by the total absence of any kind of denticulation or fold on the much longer and straight columella. The type of spiral sculpture and size of the adult shell are similar in the two genera. Another related genus is *Vicarya* d'Archiac and Haime (Yabe and Hatai, 1938, pp. 149–172), which, however, can be distinguished from the present one by the tuberculated or granulated sculpture of the whorls, a sinuated outer lip, the presence of thick callous covering and by the different shape of the aperture. *Trochocerithium* Cossmann and Sacco (Thiele, 1935, p. 215) is another related genus. However in that genus the columella is longer and curved, and also not so stout compared with the present one.

The generic name is taken from Nei-Gun from where it occurs, and the specific name is given in honor of Lieutenant-Colonel Hubert G. Schenck, in appreciation of his encouragement.

Family CASSIDIDAE
Genus SHICHIHEIA Hatai and Nisiyama, n. gen.

Shell oval, thin to moderate in thickness, never thick or heavy, whorls numbering six to eight, sculptured with granular spiral cords and smooth intercalary threads and also with smooth primary cords; suture appressed; columella stout, short, twisted, with a few distinct folds; no umbilicus; callous cover thin, broad; outer lip crenulated. A varix may be present.

Genotype: *Shichiheia etchuensis* Hatai and Nisiyama, n. sp.

Species.—*Phalium yokoyamai* Nomura and Hatai, *P. yabei* Nomura and Hatai, and *Shichiheia etchuensis* Hatai and Nisiyama.

Remarks.—The genus *Shichiheia* is distinguished from *Galeodea* Link (see Tegland, 1931, pp. 397–434), a genus well represented in the western American Tertiary, in not having a long twisted canal. *Eudolium* Dall (1909, p. 70) is said to have a straight non-reflected canal with inconspicuous siphonal fasciole, in which respects it is distinguished from *Shichiheia*, which has only a short twisted canal. *Shichiheia* is perhaps closest to *Euspinacassis* Finlay (1926, p. 230) but differs by the presence of occasional varices. *Phalium* Link (see Schenck, 1936, pp. 69–98) is another related genus. In *Phalium* the outer lip is reflected, the canal is short and recurved, the ample aperture is notched anteriorly, and the shell is heavier. To make these distinctions in fossil specimens is not always easy, unless the columellar or canal region of the shell is preserved. Even some species of *Galeodea* (Tegland, 1931, pl. 61, fig. 4) resemble quite closely *Shichiheia yokoyamai* (Nomura and Hatai) depending on the state of preservation and the angle from which the specimen is viewed. *Phalium iani* Schenck (1926, pl. 13, figs. 8, 9, 10, 11) is similar to *yokoyamai*, and should the characters of the columella or canal be not preserved, the two might easily be taken as being identical, since in spiral sculpture only the number of cords is different.

SHICHIHEIA ETCHUENSIS Hatai and Nisiyama, n. sp.
Plate 24, figures 1, 2, 7

Shell thin, oval, moderate in size, with six whorls, separated by appressed sutures; the first two nuclear whorls apparently smooth, rounded; spiral sculpture commencing on the third whorl, where six smooth, revolving flat cords, much wider

than the interspaces, are found; tuberculation commences with later growth; fifth whorl with about ten primary and about seven secondary spirals, narrower than interspaces; body-whorl with three rows of tubercles and early stage of a fourth row; all whorls roundly shouldered; varix on last whorl fairly strong, extending to columella; callous deposit thin and widespread; canal short and twisted, with distinct folds; outer lip crenulated. Height of holotype 39.5 mm., diameter 29.0 mm.

Occurrence.—Kami-Shin, Kurosedani-Mura, Nei-Gun, Toyama-Ken. Susahara formation, Miocene.

Repository.—IGPS Cat. No. 72518.

Remarks.—This species can be distinguished from *Shichiheia yokoyamai* (Nomura and Hatai) (1933, pl. 8, figs. 1, 3, 7) by the narrower shell, higher and more pointed spire, greater number of cords and finer sculpture, less swollen whorls, presence of a varix on the last whorl, and by the fewer and more rapidly enlarging as well as rounder whorls.

The generic name is given in honor of the late Dr. Shichihei Nomura, whose unfortunate death has left a great gap in the ranks of Japanese paleontologists.

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STUDIES IN QUANTITATIVE PALEONTOLOGY

II. MULTIVARIATE ANALYSIS—A NEW ANALYTICAL TOOL FOR PALEONTOLOGY AND GEOLOGY

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ABSTRACT—Multivariate analysis is the simultaneous comparison of three or more variables in order to determine the significance of their likenesses and differences. The technique has been in use for some thirteen years, but no simple account of the method has hitherto been available. An illustrative example from invertebrate paleontology is here used, but the method is applicable to any problem in geology involving several quantitatively known variables.

In recent years, increasing attention has been paid to quantitative methods in both geology and paleontology. One result of this trend has been an increased interest in statistical analysis, particularly that part of the discipline which deals with tests for the significance of the likeness and differences between two samples (or collections). These tests have, however, been rather slow in gaining acceptance and for a variety of reasons. Most of these reasons are not germane to the issue, but there is one, rather poorly defined, which seems to have been effective. There seems to have been an almost subconscious realization that the usual tests of significance involve only one, or at the most two, variables, whereas geological problems usually involve seve l variables. A more extended discussion o his phase of the problem will be found in the paper on quantitative methods by Burma (1948). A short summary will serve here.

A comparison of a single variable between two samples is readily effected by comparing their means (Simpson and Roe, 1939; pp. 192–197, 210–212). For certain simple problems, such a comparison is adequate. A better comparison of two samples may be made on the basis of two variables, provided that these variables show a notable amount of correlation as will be found to be the case in the great majority of problems. This can readily be accomplished by computing the regression line of one variable on the other for each sample, and then comparing the two regression lines (Simpson and Roe, 1939; pp. 262–280).

Both the above methods ignore the fact that much geological data, and particularly paleontological data, involves several variables and that the characteristics of a given specimen depend not on characters A, and B, and C, but on characters A, B and C considered together and simultaneously. We are usually interested in comparing objects as a whole, and not characters as such. Since the methods discussed above will not make a comparison of more than two characters simultaneously, it is obvious that they will be inadequate in such cases. Such a comparison would have to involve a comparison of the mutual regressions of several characters simultaneously.

The problem of handling multiple regressions was successfully solved by Hotelling in 1931 (Hotelling, 1931). The first person to use this method in the solution of a practical problem seems to have been M. M. Barnard, who applied it to a study of four series of Egyptian skulls (Barnard, 1935). It has been used by others since that time, but still is not widely known. Simpson and Roe's "Quantitative Zoology" which treats other statistical methods for biological data with some thoroughness, does not mention this method. Multivariate analysis is treated in a number of more advanced works on statistics (e.g., Fisher, 1946; pp. 285–289) but in these books the method is presented in a way which is not usable to a person without advanced mathematical background.

In essence, the method may be pictured thus: If we are dealing with one variable, we may use the value of this variable as a coordinate and plot the variable onto a line,

using a point for each specimen, and then study the distribution of these points. If we have two variables, we have two coordinants for our points and plot them into a plane in two dimensions. If we have three variables, our points would be plotted in a "solid" of three dimensions. If we have n variables, we use n-dimensional space. We would then study the dispersion of the points in this n-dimensional cluster, doing this for each of the two samples we wish to compare. Next we would combine our two samples and study the dispersion of the combined sample. The relative dispersions of the original and combined samples will enable us to decide whether the two samples differ significantly or whether they do not.

Fortunately, the actual computations involved in this method are all very simple. These operations are, however, rather lengthy and ordinarily it will be found that long-hand computation is much too time-consuming except possibly for a comparison of three variables. A slide rule *cannot* be used because of the low order of accuracy it allows. A calculating machine is thus a necessity in the use of this method. It should be an electrically driven model with at least ten rows of keys and preferably with automatic division and multiplication. Such a machine is suitable for calculations involving up to eight variables or so. If it is necessary to handle more than eight variables it would probably be well to use an International Business Machines calculator, feeding the data on punched cards. Ordinarily, it will be found that the number of characters to be compared can be held to a reasonable figure.

METHOD OF CALCULATION

To illustrate the calculations of multivariate analysis, we may use an example taken from the blastoids. These were collected from the Paint Creek formation near Floraville, Illinois. They are of the group commonly referred to *Pentremites godoni*, but it was soon discovered that they were susceptible to division into two groups, one of which had a somewhat stellate horizontal section associated with a rather low deltoid-standard radial ratio and another with a more rounded section and a markedly higher deltoid-standard radial ratio. The first of these we shall call *P. godoni* alpha and the second *P. godoni* beta. Comparisons of regression lines of two characters indicated that the two did not differ significantly. In spite of this, it was felt that there was a real difference between the two, so it was decided to try multivariate analysis. For this purpose, eight characters were measured on each specimen: the standard radial, length of the deltoid, the base of the radial, height of the azygous basal, length of the ambulacrum, the total height, the thickness, and the number of side plates per ambulacrum. (For an explanation of this terminology, see Burma, 1948.) In all, 20 usable specimens of *P. godoni* alpha and 20 of *P. godoni* beta were available. These two samples will hereafter be referred to as "alpha" and "beta" respectively. The original measurements are shown in Table 1. All measurements are in millimeters. In this and subsequent tables, the column headed by (1) will be the data for the standard radial; (2) the deltoid; (3) the base of the radial; (4) the azygous basal; (5) the ambulacrum; (6) the height; (7) the thickness; and (8) the number of side plates. All measurements in any one horizontal row are of one single specimen. Column (1) should always be the character on which the other characters will regress, usually the "time" character.

Since we will be dealing with regression formulae which are accurate only in straight-line relationships, we should be sure that our data fulfills this requirement. If the present data is plotted arithmetically, it will be found to show a definitely curvilinear trend. Knowing, however, that growth is commonly governed by an exponential function, we will find that the logarithms of these data will yield a plot whose trend approximates a straight line.

For that reason, we will in this case deal with the logarithms of the data rather than the original measurements. In order to deal with whole numbers and digits as low as possible, the following procedure has been adopted. Three place logarithms have been used as sufficiently accurate and each has been multiplied by 1000 to get rid of the decimal point. The size of the digits was then reduced by subtracting a number from the logarithms for each character, the same number being subtracted, for example, from

character (1) in both alpha and beta. This is important. From character (1), 700 was subtracted; from (2), 600; (3), 500; (4) 300; (5) 1000; (6), 1000; (7), 1000; and (8), 1500. This computation is then checked. This step gives the data as recorded in Table 2. From this point on, these data will be used entirely. If the original data have an essentially straight-line trend, such a step as this could be omitted.

The actual computation now begins. The first step is to obtain for each set of data, for alpha and beta, the sum of each column ($\Sigma(X)$), the sum of the square of each member of each column ($\Sigma(X^2)$), and the sum of twice the product of corresponding members of columns (1) and (2), (1) and (3), (1) and (4), and so on ($\Sigma(XY)$). To explain this last part of the computation further, in alpha, one would multiply 106 by 072, 169 by 220, 175 by 132, and so on, and then sum these products. With a calculating machine, $\Sigma(X)$,

TABLE 1.—ORIGINAL DATA

P. godoni alpha								*P. godoni* beta							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6.4	4.7	4.1	3.0	10.3	12.3	11.5	33	5.5	4.9	4.0	2.5	10.0	12.0	10.6	33
7.4	6.6	4.0	2.5	13.0	14.6	12.0	41	6.2	4.7	4.0	2.6	10.1	12.4	11.1	34
7.5	5.4	4.1	2.5	11.5	14.2	11.5	37	6.6	6.5	4.0	2.7	12.5	14.4	12.0	41
7.7	5.4	4.8	3.5	11.6	14.5	12.4	37	7.0	5.9	3.9	2.4	12.2	14.4	11.3	38
8.8	7.4	5.9	3.5	14.5	17.2	16.1	47	7.4	6.4	5.0	3.6	12.2	15.1	12.9	38
9.0	7.5	5.6	3.4	15.1	17.7	16.0	43	7.5	9.0	4.8	3.3	16.0	16.5	15.9	50
9.3	8.4	6.5	4.4	16.9	20.0	19.0	50	7.5	7.7	4.6	3.2	14.9	17.0	14.5	49
9.4	8.2	5.5	4.1	16.6	19.4	17.5	47	7.9	7.0	4.9	3.3	14.2	16.6	15.1	43
9.5	7.9	4.6	3.5	16.0	18.8	15.3	47	8.3	7.4	4.9	3.0	14.9	16.4	15.4	49
9.6	8.6	5.1	3.5	17.0	19.0	17.5	53	8.4	7.4	5.4	4.0	14.0	16.5	15.5	42
9.8	8.6	5.5	3.2	16.9	19.7	16.4	52	8.4	8.2	5.3	3.6	16.2	19.2	16.2	48
9.5	8.0	6.0	4.4	16.4	19.5	17.5	47	8.5	7.8	4.6	3.5	14.5	17.6	14.7	46
10.0	9.6	6.0	4.3	19.0	21.0	18.8	52	8.5	8.6	4.4	3.3	16.8	18.6	15.3	53
10.1	9.0	5.4	3.7	18.5	19.8	17.6	52	8.5	7.9	5.0	3.6	15.9	17.5	16.8	48
10.1	8.9	6.1	4.5	18.0	19.7	19.5	54	8.5	9.6	4.9	3.4	17.7	19.0	16.4	50
10.4	8.7	5.2	3.2	17.5	19.0	16.8	53	8.6	8.7	4.5	3.5	16.3	18.0	15.0	49
10.5	8.2	6.0	4.4	17.2	19.5	17.5	54	8.6	8.1	5.5	4.0	15.8	18.6	16.2	46
10.7	8.5	4.7	3.5	16.9	19.5	16.5	54	8.6	9.5	5.3	3.9	18.0	19.5	17.0	57
12.4	9.2	6.6	5.0	19.9	23.6	18.7	52	9.5	8.9	5.3	4.0	16.5	18.4	17.5	53
8.3	6.5	5.0	3.5	13.9	15.3	14.5	42	10.8	9.9	5.5	4.1	19.5	21.9	19.4	58

TABLE 2.—ADJUSTED LOGARITHMS OF DATA

P. godoni alpha								*P. godoni* beta							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
106	072	113	177	013	090	061	019	040	090	102	098	000	079	025	019
169	220	102	098	114	164	079	113	092	072	102	115	004	093	045	031
175	132	113	098	061	152	061	068	120	213	102	131	097	158	079	113
186	132	181	244	064	161	093	068	145	171	091	080	086	158	053	080
244	269	271	244	161	236	207	172	169	206	199	256	086	179	111	080
254	275	248	231	179	248	204	133	175	354	181	219	204	217	201	199
268	324	313	343	228	301	279	199	175	286	163	205	173	230	161	190
273	314	240	313	220	288	243	172	198	245	190	219	152	220	179	133
278	298	163	244	204	274	185	172	219	269	190	177	173	215	188	190
282	334	208	244	230	279	243	224	224	269	232	302	146	217	190	123
291	334	240	205	228	294	215	216	224	314	224	256	210	283	210	181
278	303	278	343	215	290	243	172	229	292	163	244	161	246	167	163
300	382	278	333	279	322	274	216	229	334	143	219	225	270	185	224
304	354	232	268	267	297	246	216	229	298	199	256	201	243	225	181
304	349	285	353	255	294	290	232	229	382	190	231	248	279	215	199
317	340	216	205	243	279	225	224	234	340	153	244	212	255	176	190
321	314	278	343	236	290	243	232	234	308	240	302	199	270	210	163
329	329	172	244	228	290	217	232	234	378	224	291	255	290	230	256
393	364	320	399	299	373	272	216	278	349	224	302	217	265	243	224
219	213	199	244	143	185	161	123	333	396	240	313	290	340	288	263

$\Sigma(X^2)$, and $\Sigma(XY)$, may be obtained simultaneously for each pair of columns, greatly reducing the work involved. The result for the data in hand is given in Table 3. Do *not* "round off" any results of computations to less than ten figures on any place except where it is done in this sample computation. Such random dropping of figures can have a very adverse effect on the accuracy of the method.

This computation is checked by the following method: For each pair of columns used in computing $\Sigma(XY)$, add the corresponding figures in each row, square this sum, and add the squares for the entire columns $(\Sigma(X+Y)^2)$. For example in alpha, columns (1) and (2), $106+072=178$, $(178)^2=31{,}684$; $169+220=389$, $(389)^2=151{,}321$; and so on, these successive squares being summed. The following relation should then hold true,

$$\Sigma(X+Y)^2=\Sigma(X^2)+2\Sigma(XY)+\Sigma(Y^2).$$

The right hand terms have already been calculated and the individual terms need only be added. If the two sides of the equation are not equal, the computation for those two columns must be redone. This and all other checks mentioned *must* be done. A single, small, undetected error early in the computation will mean hours of work wasted to obtain an erroneous result. The frequent checks which are recommended will prevent this.

The next step is to obtain $\Sigma(X)$, $\Sigma(X^2)$, and $\Sigma(XY)$ for the combined data, that is, by combining both samples or collections into one. This is very easily done by adding the results already obtained for $\Sigma(X)$, $\Sigma(X^2)$, $\Sigma(XY)$ and $(\Sigma(X+Y)^2)$ for alpha and beta. This has been done in Table 4. This addition is checked as before,

$$\Sigma(X+Y)^2=\Sigma(X^2)+2\Sigma(XY)+\Sigma(Y^2).$$

The calculation of the regression equation is next. This equation has the form $Y=a+bX$ in which we must calculate the coefficients a and b.

$$a=\frac{\Sigma(Y)\Sigma(X^2)-\Sigma(X)\Sigma(XY)}{N\Sigma(X^2)-[\Sigma(X)]^2},$$

$$b=\frac{N\Sigma(XY)-\Sigma(X)\Sigma(Y)}{N\Sigma(X^2)-[\Sigma(X)]^2}.$$

In these equations, X is the value for column (1) and Y for the other columns. N is the total number of specimens in the combined

TABLE 3

P. godoni alpha

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Sigma(X)$	5,291	5,652	4,450	5,173	3,867	5,107	4,041	3,419
$\Sigma(X^2)$	1,483,209	1,737,058	1,071,792	1,462,603	862,787	1,395,943	918,595	661,581
$\Sigma(XY)$		3,187,580	2,472,956	2,878,762	2,231,676	2,870,010	2,298,640	1,955,956
Check		6,407,847	5,027,957	6,824,574	4,577,672	5,749,162	4,700,444	4,100,746
				P. godoni beta				
$\Sigma(X)$	4,010	5,566	3,552	4,460	3,339	4,507	3,381	3,202
$\Sigma(X^2)$	885,022	1,704,298	676,304	1,088,940	673,421	1,096,807	666,861	600,928
$\Sigma(XY)$		2,426,908	1,519,658	1,935,988	1,513,338	1,960,018	1,519,196	1,428,814
Check		5,016,228	3,080,984	3,909,940	3,071,781	3,941,847	3,071,079	2,914,764

TABLE 4

Combined data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Sigma(X)$	9,301	11,218	8,002	9,633	7,206	9,614	7,422	6,621
$\Sigma(X^2)$	2,368,231	3,441,356	1,748,096	2,551,543	1,536,208	2,492,750	1,585,456	1,262,509
$\Sigma(2XY)$		2,807,244	1,996,307	2,407,375	1,872,507	2,415,014	1,908,918	1,692,385
Check		11,424,075	8,108,941	9,734,524	7,649,453	9,691,009	7,771,523	7,015,510
a		55.548	46.582	51.3554	−42.663	37.2389	−21.6328	−7.39789
b		0.967 2170	0.660 0068	0.814 835	0.958 231	0.873 502	0.891 013	0.743 674

sample, in this case 40. a and b are calculated for each pair of columns, (1) and (2), (1) and (3), (1) and (4), and so on. The calculated value of these coefficients is shown on Table 4.

A sample calculation for the coefficient "a" for columns (1) and (2) is as follows:

$$a=\frac{(11218)(2368231)-(9301)(2807244)}{(40)(2368231)-(9301)(9301)}$$

$$=\frac{456638941}{8220639}=55.548.$$

These coefficients should be checked by refilled in by subtracting a given computed value of Table 5 from its corresponding observed value of Table 2. For example, in column (2), the first item will be $072-158=-82$, the second is $220-219=1$, and so on. Be sure to keep proper account of plus and minus signs.

After Table 6 is completed, the sum of each column, and the sum of the squares of each item for each column [$\Sigma(X)$, $\Sigma(X^2)$] is computed as is shown in Table 7. These are computed exactly as in Table 3. In obtaining the sums of the columns, due account must be taken of plus and minus signs. To check,

TABLE 5

P. godoni alpha								*P. godoni* beta							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
106	158	117	138	059	130	73	071	040	094	073	084	−004	072	014	022
169	219	158	189	119	185	129	118	092	145	107	126	045	118	060	061
175	225	162	194	125	190	134	123	120	172	126	149	072	142	085	082
186	235	169	203	136	200	144	131	145	196	142	170	096	164	108	100
244	292	208	250	191	250	196	174	169	219	158	189	119	185	129	118
254	301	214	258	201	259	205	181	175	225	162	194	125	190	134	123
268	315	223	270	214	271	217	192	175	225	162	194	125	190	134	123
273	320	227	274	219	276	222	196	198	247	177	213	147	210	155	140
278	324	230	278	224	280	226	199	219	267	191	230	167	229	173	155
282	328	233	281	228	284	230	202	224	272	194	234	172	233	178	159
291	337	239	288	236	291	238	209	224	272	194	234	172	233	178	159
278	324	230	278	224	280	226	199	229	277	198	238	177	237	182	163
300	346	245	295	245	299	246	216	229	277	198	238	177	237	182	163
304	350	247	298	249	303	249	219	229	277	198	238	177	237	182	163
304	350	247	298	249	303	249	219	229	277	198	238	177	237	182	163
317	362	256	308	261	314	261	228	234	282	201	242	182	242	187	167
321	366	258	312	265	318	264	231	234	282	201	242	182	242	187	167
329	374	264	318	273	325	272	237	234	282	201	242	182	242	187	167
393	436	306	370	334	381	329	285	278	324	230	278	224	280	226	199
219	267	191	230	167	229	173	155	333	378	266	323	276	328	275	240

calculation, a matter of a few moments using a calculating machine.

For the next step (Table 5), column (1) (our X column) is copied directly from Table 2 for both alpha and beta. Columns (2) to (8) are filled in with the *calculated* value (Y) of that particular character which would correspond to the *observed* value of X, column (1), using the appropriate regression equation. For example, the equation for calculating the values for column (2) of alpha would be $Y=55.548+0.9672170X$ and the first value in column (2) would be $55.548+(0.9672170)\ (160)=158.0730$. This is rounded off to 158. In this manner, all of Table 5 is filled in.

After this is done, Table 6 is computed. In this Table, column (1) is dropped and is not used hereafter. The other columns are add corresponding columns of $\Sigma(X)$ of alpha and beta together. The answer should be close to zero and never greater than $\pm\frac{1}{2}N$, in this case, ± 20.

The next step is to obtain the sum of the cross products of each pair of columns as shown in Table 8, that is, $\Sigma(XY)$ for columns (2) and (3), (2) and (4), (2) and (5) . . . , (3) and (4), (3) and (5), and so on. In Table 8 these sums of cross products (ΣXY) are shown in the corresponding row and column, for example, the item in row (4) and column (6) is the $\Sigma(XY)$ for columns (4) and (6). These sums of products are calculated just as the $\Sigma(XY)$ in Table 3. The diagonal items are the sum of the squares of the corresponding columns. These calculations are checked by calculating $\Sigma(X+Y)^2$ for each pair of columns of Table 8 as shown

TABLE 6

P. godoni alpha							*P. godoni* beta						
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
−86	− 4	39	−46	−40	−12	−52	− 4	29	14	4	7	11	− 3
1	−56	−91	− 5	−21	−50	− 5	−73	− 5	−11	−41	−25	−15	−30
−93	−49	−96	−64	−38	−73	−55	41	−24	−18	25	16	− 6	31
−103	12	41	−72	−39	−51	−63	−25	−51	−90	−10	− 6	−55	−20
−23	63	− 6	−30	−14	11	− 2	−13	41	67	−33	− 6	−19	−38
−26	34	−27	−22	−11	− 1	−48	129	19	25	79	27	67	76
9	90	73	14	30	62	7	61	1	11	48	40	27	67
− 6	13	39	1	12	21	−24	− 2	13	6	5	10	24	− 7
−26	−67	−34	−20	− 6	−41	−27	2	− 1	−52	6	−14	15	35
6	−25	−37	2	− 5	13	22	− 3	38	68	−26	−16	12	−36
− 3	1	−83	− 8	3	−23	7	42	30	22	38	50	32	22
−21	48	65	− 9	10	17	−27	15	−35	6	−16	9	−15	0
36	33	37	34	23	28	0	57	−55	−19	48	33	3	61
4	−15	−31	18	− 6	− 3	− 3	21	1	18	24	6	43	18
− 1	38	54	6	− 9	41	13	105	− 8	− 7	71	42	33	36
−22	−40	−105	−18	−35	−36	− 4	58	−48	2	30	13	−11	23
−52	20	30	−29	−28	−21	1	26	39	60	17	28	23	− 4
−45	−92	−75	−45	−35	−55	− 5	96	23	49	73	48	43	89
−72	14	27	−35	− 8	−57	−69	25	− 6	24	− 7	−15	17	25
−54	8	14	−24	−44	−12	−32	18	−26	−10	14	12	13	23

TABLE 7

P. godoni alpha

	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Sigma(X)$	−577	26	−166	−352	−261	−242	−366
$\Sigma(X^2)$	43,765	39,992	65,674	20,058	12,417	28,278	20,652
$\Sigma(X)$	576	−25	164	349	259	242	368
$\Sigma(X^2)$	59,108	17,981	29,380	29,177	12,979	17,084	31,994
alpha minus beta	−1,153	51	−330	−701	−520	−484	−734
Combined data							
(X^2)	102,873	57,973	95,054	49,235	25,396	45,362	52,646
(X)	−1	1	−2	−3	−2	0	2

TABLE 8

P. godoni alpha

	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(2)	43,765	6,219	4,648	28,481	19,249	24,151	25,884
(3)		39,992	38,085	6,899	9,443	23,253	914
(4)			65,674	8,511	11,408	27,143	−916
(5)				20,058	13,248	17,763	15,909
(6)					12,417	13,594	9,161
(7)						28,278	14,088
(8)							20,652
			P. godoni beta				
(2)	59,108	−1,022	11,336	39,198	23,187	23,068	37,922
(3)		17,981	16,487	−1,406	483	7,690	−4,128
(4)			29,380	3,305	4,971	11,084	1,210
(5)				29,177	17,255	16,411	27,796
(6)					12,979	9,201	15,414
(7)						17,084	15,934
(8)							31,994

in Table 9. This sum, $\Sigma(X+Y)^2$, will equal $\Sigma X^2+2\Sigma(XY)\Sigma Y^2$, these last items having been already been calculated.

We are now ready to set up a determinate which is shown in Table 10. The diagonal terms (column (2), row (2); column (3), row (3), etc.) in this determinant are the sums of the squares of the corresponding columns of the combined data. The other items are the sums of the corresponding items of alpha and beta in Table 8, e.g., column (3), row (2) of the determinant equals 6219

TABLE 9

(3)	(4)	(5)	(6)	(7)	(8)
96,195	118,735	120,785	94,680	120,345	116,185
	181,836	73,848	71,295	114,776	62,472
		102,754	100,907	148,238	84,494
			58,971	83,862	72,528
				67,883	51,391
					77,106
		P. godoni beta (Check)			
75,045	111,160	166,681	118,461	122,328	166,946
	80,335	44,346	31,926	50,445	41,791
		65,167	52,301	68,632	63,794
			76,666	79,083	116,763
				48,465	5,801
					80,946

TABLE 10

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Difference
(2)	102,873	5,197	15,984	67,679	42,436	47,219	63,806	57.65
(3)		57,973	54,572	5,493	9,926	30,943	−3,214	−2.55
(4)			95,054	11,816	16,379	38,227	294	16.50
(5)				49,235	30,503	34,174	43,705	35.05
(6)					25,396	22,795	24,575	26.00
(7)						45,362	30,022	24.20
(8)							52,646	36.70

TABLE 11

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Difference
(2)	320.73[1]	16.203	49.835	211.01	132.30	147.21	198.93	0.1797
	82110	24563	03524	00945	72795	97528	48260	4160
(3)		240.23	223.80	8.6331	32.394	118.87	−26.796	−0.0227
		0005	43107	9138	75706	59172	77691	38198
(4)			206.11	−3.0655	12.300	20.791	−17.576	0.0612
			1862	2440	96980	41076	32891	84574
(5)				68.013	34.447	31.561	28.012	−0.0366
				31209	18632	52825	23093	56345
(6)					74.185	−25.303	−21.920	0.0466
					18053	72986	64849	98337
(7)						86.534	32.900	0.0174
						20859	38940	02250
(8)							98.469	0.0293
							81712	38193

[1] To conserve space, 320.7382110 is written
320.73
82110

$+(-1022)=5197$. The rest of the determinant is filled in in this manner. The figures for the difference column are obtained from $\Sigma(X)$ of alpha minus $\Sigma(X)$ of beta, as shown on Table 7, and divided by $\frac{1}{2}N$, in this case, 20. Thus the first item of the difference column is $-1153/20=57.65$. The calculations involved should be checked by recalculation.

There are several ways to solve a determinant set up in this manner. The one chosen here is probably the simplest and shortest method. First an auxiliary determinant is set up as shown in Table 11. This is accomplished in the following manner. In giving these directions, which are rather complex, we will refer to the "determinant" with numbered and lettered squares as shown in Table 12. In this table, the diagonal terms are given letters and other terms, arabic numerals. The terms of the difference column are shown by roman numerals.

TABLE 12

A	1	2	4	7	11	16	I
	B	3	5	8	12	17	II
		C	6	9	13	18	III
			D	10	14	19	IV
				E	15	20	V
					F	21	VI
						G	VII

The diagonal term A of the auxiliary is the square root of the original term ($\sqrt{102873}=320.7382110$). Term "1" of the auxiliary is the original term divided by auxiliary A ($5197/320.7382110=16.20324563$). Auxiliary B is equal to square root of the original B minus the square of auxiliary term 1. Auxiliary C and the rest of the diagonal terms equal the square root of the original diagonal terms minus the sum of the squares of the auxiliary terms in the column above it. Terms 2, 4, 7, 11, 16 and I of the auxiliary equal the original term divided by auxiliary A. Other terms are calculated in the following manner; all terms used in these calculations use auxiliary terms calculated as shown above.

$$\text{Auxiliary } 6=\frac{(2)(4)+(3)(5)}{C},$$

$$\text{Auxiliary } 19=\frac{(4)(16)+(5)(17)+(6)(18)}{D},$$

$$\text{Auxiliary V}=\frac{(7)(\text{I})+(8)(\text{II})+(9)(\text{III})+(10)(\text{IV})}{E}.$$

Again, all figures in these calculations are those of the *auxiliary* determinant. All the values of the auxiliary determinant are checked by recalculation.

The solution of this auxiliary determinant for B values is next accomplished (not to be confused with square B of Table 12). In this solution, we begin at the bottom of the determinant and work up. Again we will use the square lettering and numbering system of Table 12 and referring entirely to the terms of the auxiliary determinant. B_8, the first B to be calculated, equals

$$\text{VII}/G,\left(\frac{0.029338193}{98.46981712}=0.000297940973\right).$$

$$B_7=\frac{\text{VI}-(21)(B_8)}{F},$$

$$B_6=\frac{\text{V}-(20)(B_8)-(15)(B_7)}{E}.$$

The rest of the B's are calculated by the same system. Note that 21, 20, and 15 in the calculation of B_7 and B_6 refer to the terms in squares numbered in that manner in Table 12. The values of these B terms for our problem are shown in Table 13. These B's

TABLE 13

$B_2=0.000719136629$
$B_3=0.000402709216$
$B_4=0.000253196212$
$B_5=0.001081004484$
$B_6=0.000747476560$
$B_7=0.000087825110$
$B_8=0.000297940973$
$\Sigma BD=0.04126785739$

are then multiplied by the corresponding value in the difference column (D) of the *original* determinant

$$B_2D_2=(0.000719136629)(57.65)$$

and these successive products are added ($\Sigma(BD)$). This sum is shown in Table 13 also.

The calculation of R^2 is then possible, which equals

$$\frac{N_1N_2}{N_1+N_2}\Sigma BD.$$

N_1 and N_2 are the numbers of specimens in the respective samples. The value of R^2 turns out to be, in this case, 0.4126785739. F is next calculated according to the formula

$$F=\frac{n-p+1}{p}\cdot\frac{R^2}{1-R^2}$$

(n is the number of degrees of freedom; in this type of problem it will be N_1+N_2-2; p is the number of characters originally used minus 1. In this particular problem $n=20+20-2$ or 38 and $p=8-1$ or 7). Thus F equals 3.212.

The final step in the process is to look up the corresponding F in a table of variance ratios. That of Fisher and Yates in "Statistical Tables for Biological, Agricultural and Medical Research," p. 33, is eminently satisfactory. This table has columns numbered n_1 and rows numbered n_2 ($n_1=p$, $n_2=n-p+1$, both as in the paragraph above). The 1% table should be used for almost all problems. If we look for our particular values in this table ($n_1=7$, $n_2=38$) we find the consequent to be, by interpolation, 3.284. If F is greater than the value in the table, it means that the two samples would differ as much as they do by chance, less than once in a hundred times. In this case, the F is slightly smaller than the table value, but not greatly. We may in this case, then, conclude that the differences observed in these two samples are probably significant.

Although the example above is taken from paleontology, the method is applicable to any two series of samples of several variables. For example, the method could be used to tell whether the difference in proportions of several different kinds of heavy minerals in two formations was significant or not. Although the method is laborious, it does have the advantage of reducing large masses of data into a usable form.

ACKNOWLEDGEMENTS

The writer is greatly indebted to Dr. K. J. Arnold for his patient help in guiding him through the steps of this statistical technique.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 104–105, JANUARY 1949

PALEONTOLOGICAL NOTES

A NEW SPECIES OF *MYTILUS* FROM THE PLIOCENE OF HUMBOLDT COUNTY, CALIFORNIA[1]

YORK T. MANDRA
University of California

In the summer of 1946 Mr. B. Ogle collected a marine Pliocene fauna from a fine grained, poorly compacted and poorly cemented, buff to gray arkosic sandstone on Boulder Creek (Blue Lake Quadrangle, Humboldt Co.) California. Some of the more common species are:

Anadara trilineata (Conrad)
Cardium (*Clinocardium*) *nuttallii* Conrad
Crepidula princeps Conrad
Macoma nasuta Conrad
M. secta Conrad
Olivella biplicata (Sowerby)
Panope generosa Gould
Patinopecten caurinus (Gould)
Saxidomus nuttallii Conrad
Schizothaerus nuttallii (Conrad)

A B

FIG. 1.—*Mytilus highoohiae*, ×1. a. lateral view, b. profile view from ventral side.

[1] A contribution from the Museum of Paleontology of the University of California, Berkeley, California.

In addition to the preceding Ogle recognized a new species of *Mytilus*, but did not describe it. Because of its distinctive character, it is hereby described.

A review of the species of *Mytilus* present in the Cenozoic of Western North America indicates that this new species differs from all those previously described either in outline, proportions, or by the number of divaricate ribs.

The following species were reviewed:

M. arnoldi Gabb
M. ascia Gabb
M. buwaldana Van Winkle
M. californianus Conrad
M. coalingensis Arnold
M. dichotomus Cooper
M. edulis Linnaeus
M. humerus Conrad
M. inezensis Conrad
M. kewi Nomland
M. loeli Grant
M. mathewsonii Gabb
M. mathewsonii var expansus Arnold
M. merriami Clark
M. middendorffi Grewingk
M. multiradiatus (Gabb)
M. perrini Clark
M. schenki Hanna & Hertlein
M. snohomishensis Weaver
M. trampasensis Clark
M. vancouverensis Clark & Arnold
M. washingtonensis Clark
M. watersi Etherington

DESCRIPTION

Genus MYTILUS Linnaeus 1758
MYTILUS HIGHOOHIAE[2] Mandra, n. sp.
Text Figure 1

Points of greatest inflation and height near center; ligament opisthodetic; about forty prominent, rounded divaricate ribs; line of divarication bisects height of shell; interspaces half width of ribs; height of ribs one quarter of width; growth lines closely spaced; gibbous; anterior margin gently concave; and dorsal margin strongly convex.

[2] Pronounced hī'g. wē. i.

DIMENSIONS (IN MILLIMETERS)

	length	height	thickness	Position of change of curvature (measured from umbo)	Position of greatest inflation (measured from umbo)
Holotype 35518	71.0	38.0	21.9 one valve	35	34
Paratype 35519	78.0	38.0	21.0 one valve	35	approx. 32
Paratype 35520	74.1	40.0	19.0 one valve	35	30
Paratype 35521	76.8	38.4	34.0 two valves	36	27
Paratype 35522	54.7	35.2	24.8 two valves	28	26
Paratype 35523	71.1	36.4	51.0 two valves	32	33

This species is close to *M. californianus* and *M. middendorffi* in outline, but the divaricate ribs of *M. highoohiae* are distinctive. *M. highoohiae* also resembles *M. inezensis*, but the latter has about eighty fine ribs instead of the forty present in *M. highoohiae*.

Locality.—All specimens from U. C. Mus. Pal. loc. A4234. This locality is at 734.7—2036.0 (Grid Zone "G," standard grid coordinates) in the Blue lake Quadrangle, (War Department, Corps of Engineers, U. S. Army, 1943 edition). The strata at this locality are of lower Pliocene to lower middle Pliocene age (Ogle, unpublished thesis, 1947, on file in Univ. of Calif. Library).

NOMINATIONS FOR OFFICES IN THE PALEONTOLOGICAL SOCIETY FOR 1950

In accordance with the provisions of Chapter III, Section 2, of the By-Laws, the Council of the Paleontological Society announces the following nominations for offices in the Society for 1950:

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 1, PP. 106–108, JANUARY 1949

NOMENCLATURAL NOTES

SPECIES WITHOUT A GENUS?

OTTO HAAS
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In a recent article Mertens (1947) discusses genera without species and species without a genus. As an example for the latter he chooses "*menagensis*," proposed, without a generic name, by Nachtrieb for the loris later named *Nycticebus menagensis*. Stressing the fact that Nachtrieb refrained from deciding on the generic affinities of his form, Mertens concludes that "even species without a genus, whose family relations are established, should be acknowledged with their original specific name and with its authorship" (Translation from the German).

From the above version it is not quite clear whether Mertens postulates such a procedure under existing Rules or as a proposal for their amendment. Anyway, there cannot be the slightest doubt that it would be inconsistent with existing Rules, since their Art. 2 requires a binomial name for species. Thus, a species name that does not include a generic name is certainly invalid.

To avoid this consequence, an author establishing a species, whose generic affinities appear doubtful, and refraining (as Nachtrieb did) from creating a new genus because of uncertainty of the generic characters, will have to attach his new species, though doubtfully, to some more or less related existing genus, leaving the definite generic reference to future workers who may be expected to have more complete material at their disposal.

REFERENCE

MERTENS, ROBERT, 1947, Artenlose Gattungen und gattungslose Arten im zoologischen Schrifttum: Senckenbergiana, vol. 28, n. 1–3, pp. 95–98.

ON THE NOMENCLATURE AND GENERIC POSITION OF *NAUTILUS BECCARII* LINNÉ (FORAMINIFERA, "ROTALIIDAE")

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and
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Cole (1947) recently has revised certain of the rotaliid foraminiferal genera, reviving the name *Turbinulina* Risso for the group of "*Rotalia*" *beccarii* (Linné) (Linné, 1758, p. 1758, p. 710). In this separation he followed the conclusions on morphology made by Davies (1932). We believe this action to be premature, on considerations both nomenclatural and biological.

Nomenclaturally, the following sequence of names is involved, three of which have actual or potential priority over *Turbinulina*.

AMMONIA Brünnich, 1772

Ammonia BRÜNNICH, 1772, Zoologiae Fundamenta, p. 246, (*fide* Winckworth, 1945, p. 116).

Genotype (here designated): *Ammonia beccarii* (Linné) = *Nautilus beccarii* Linné.

Brünnich's names are under consideration by the International Commission on Zoological Nomenclature (Winckworth, 1945, pp. 113–117), and may prove to be acceptable. If so, validation of *Ammonia* for the group of *Nautilus beccarii* Linné is indicated as the simplest course available. Winck-

worth shows that *Ammonia* is based upon *N. beccarii* and *Nautilus spirula* Linné. Designation of the latter as genotype necessitates either suppression of the later cephalopod genus *Spirula* Lamarck, 1799, or an appeal to the International Commission for suspension of the Règles.

HAMMONIUM Fichtel and Moll, 1798

Hammonium FICHTEL and MOLL, 1798, Testacea microscopica aliaque minuta ex generibus Argonauta et Nautilus, pp. 13, 15, vi.

Genotype (by monotypy): *Hammonium beccarium* (Linné) = *Nautilus beccarii* Linné, 1758.

Hammonium is not invalidated by the prior *Hammonia* Browne, 1789 (Hist. Jamaica, ed. 2, p. 397), a gastropod genus apparently equivalent to *Planorbis* Müller, 1774, the difference of spelling being sufficient for differentiation (International Code of Zoological Nomenclature, Article 36, Recommendation *a*). *Hammonium* is in part equivalent to *Hammonia* Soldani, 1780, but the latter name is nomenclaturally unavailable, having been proposed in the plural in a non-binomial work, and need not be considered here.

STREBLUS Fischer, 1817

Streblus FISCHER, 1817, Soc. Imp. Nat. Moscou Mém., tome 5, p. 449.

Genotype (by monotypy): *Streblus beccarii* (Linné) = *Nautilus beccarii* Linné, 1758 (according to Ellis and Messina, 1940).

TURBINULINA Risso, 1826
(*?ex* d'Orbigny MS)

Turbinulina RISSO, 1826, Hist. nat. prin. prod. de l'Europe mér., tome 4, p. 18.

Genotype (by subsequent designation, Cole, 1947): *Turbinulina italica* (d'orbigny) = *Rotalia* (Turbinuline) *italica* d'Orbigny, 1826 = *Nautilus beccarii* Linné, 1758 (*fide* Parker, Jones and Brady, 1871). [The designation of *N. beccarii* Linné by A. M. Davies, 1935, is invalid, because this name does not appear in Risso's original list.]

Biologically, the case is less clear. The genotype of *Rotalia* Lamarck, 1804 (Ann. Mus. Paris, vol. 5, p. 183) is *R. trochidiformis* Lamarck, 1804 (*ibid.*, p. 184; figured, *ibid.*, vol. 8, 1806, pl. 62, fig. 8), from the Eocene of the Paris Basin, by designation of Galloway and Wissler, 1927 (Jour. Paleontology, vol. 1, p. 59). L. M. Davies has shown (1932, pp. 411–412) that *R. trochidiformis* Lamarck is structurally distinct in some details from "*Rotalia*" *beccarii* (Linné). Cole (1947) further showed that the internal structure of "*Lockhartia*" *cushmani* Applin and Jordan (1945, p. 143, pl. 21, figs. 5 a–b) is intermediate in some respects between *Lockhartia* Davies (1932) and *Rotalia* Lamarck. Neither author (nor to our knowledge any other) has made over-all studies of rotalioid species sufficient to establish generic limits. Glaessner (1945, p. 157) has aptly summarized the situation as follows:

> L. M. Davies (1933) [1932] refers to the "astral lobe" as the most characteristic feature of *Rotalia*. In *R. beccarii* L., . . . which differs from *R. trochidiformis* Lam. . . . mainly in the weaker development of the pillars, the astral lobe is often clearly seen, but its umbilical margin is open and conceals the aperture, while the internal foramen is placed in the septum much nearer to the periphery, above the incomplete partition marked on the surface by the astral furrow. The astral lobe is probably present, although less conspicuous, in the group of *R. calcar* d'Orbigny, in which the peripheral margin of each chamber is extended into a spine. The generic names *Streblus* Fischer and *Calcarina* d'Orbigny . . . have been used for these two groups of Tertiary and Recent rotalids [*sic*] but there are transitions between them, the Eocene genotype, and the more complex group of *R. schroeteriana* (Parker and Jones) which make it inadvisable to introduce further names without a re-examination of all these important forms.

It cannot be overstressed that the basis for generic separation is the group-relationship of species, based on the summation of both external and internal morphological characters. Until that basis is established, erection or resurrection of isolated genera is likely to cause confusion and may even result in the unjustified suppression as synonyms of widely known and well founded generic names. We therefore believe that the nomenclature of *Rotalia* Lamarck should be held in abeyance, pending a morphologic treatment of the subfamily Rotaliinae. The generic name should be written with quotation marks for species of the "*Rotalia*" *beccarii* group as well as for other rotaliine generic assemblages of currently uncertain position.

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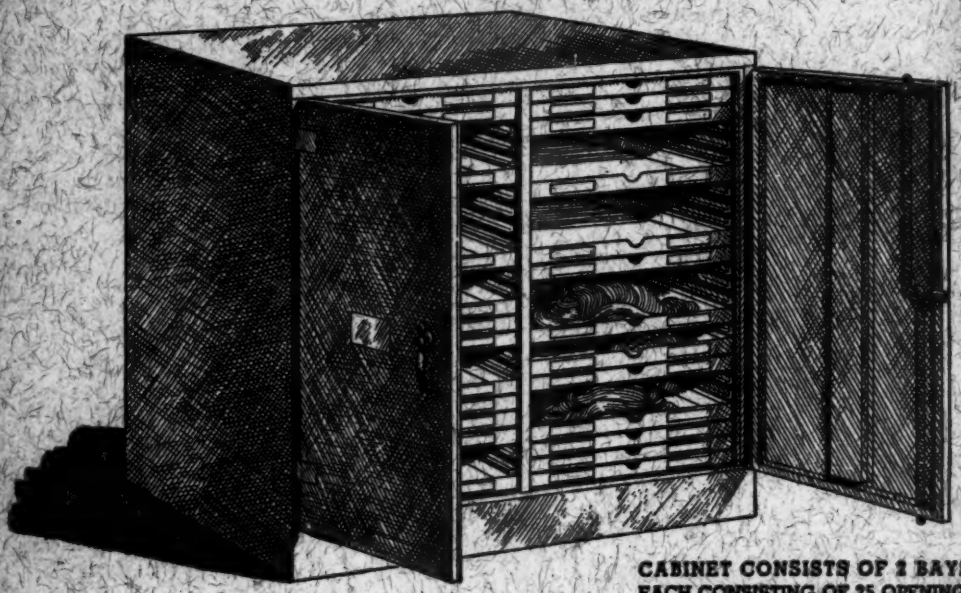
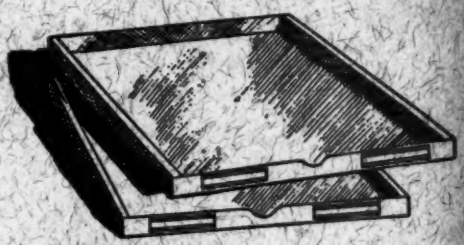
PALEONTOLOGY *and* GEOLOGY CASES
with removable steel trays



CABINET CONSISTS OF 2 BAYS,
EACH CONSISTING OF 25 OPENINGS
FOR TRAYS — TOTAL 50 OPENINGS

NOW AVAILABLE—all steel cabinets and trays. Made of furniture steel, welded construction, with lock. Doors furnished with 3 point locking device. VERMIN PROOF—MOISTURE PROOF



"This will be on display at the St. Louis convention March 14-17, 1949."

Green or Gray finish—Shipped set up ready for use

For complete information, write

W. B. WOOD COMPANY
CONTRACT DEPARTMENT
43 CLINTON STREET
NEWARK 2, NEW JERSEY, U.S.A.